A NOTE ON PRODUCTIVITY AND THE REAL EXCHANGE RATE

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Let me begin with a thumbnail sketch of the recent "real exchange rate history" of Russia. Prior to the currency and banking crisis of 1998, the ruble was highly appreciated (i.e., the dollar was expensive) in real terms. Then came the crisis, which brought with it a sharp devaluation (both nominal and real) of the ruble. This devaluation served as a welcome stimulus to the production of tradable goods (whose ruble prices tend to move along with the price of the dollar). Most of the resulting increase in tradable goods production was concentrated on import substitute goods; it is quite commonly true in similar situations that the response of export production has been more gradual (though yet, in the end less important) than that of import substitutes.

A special place in our story must be given to oil and gas exports which began to boom in mid-1999. That boom was due to the sharp increase of world prices of these commodities. It produced an abundance of dollars, which resulted in the dollar becoming progressively cheaper in real terms. By now the oil price boom appears to be over, making it very unlikely that booming oil prices will account for a steady and continuing real appreciation of the ruble over

the coming years. Yet many economists believe that such a continuing appreciation is indeed in the cards. When pressed as to its likely source they typically respond "increase in productivity."

This intuitive response provides the starting point for the present paper. In it we will ask questions like:

a) What links exist between productivity improvements and movements of the real exchange rate?

b) Are these links general and unidirectional, so that we can expect all productivity improvements to lead in the direction of RER appreciation, or complicated, with some of the improvements causing the RER to appreciate, while others cause it to depreciate?

c) Are these links always the same, or do they depend on some degree on the state of the economy or the labor market? In particular, do productivity increases have different effects on real exchange rate in periods of full employment (labor market equilibrium reflecting flexible adjustment of nominal and real wages) than they do in periods of less-than-full employment (labor-market disequilibrium, reflecting some sort of rigidities in the wage adjustment process)?

I. Is RER Appreciation Typical In Periods of Rapid Growth?

Figure 1 is an excellent starting point for our journey. It shows how Japan's real exchange rate fell almost continuously during a period when the Japanese economy was experiencing very rapid growth. (Readers should note that the real exchange rate is here defined as "real Yen per real dollar". A reduction in this rate means dollars are cheaper in real terms, and thus means an appreciation of the Yen.)

The high rate of growth of the Japanese economy in this period is evidence of rapidly increasing productivity. Figure 1 thus may be considered an illustration of what people have in

mind when they contemplate a firm and unidirectional link between productivity improvement and a decline in the real price of foreign currency.

But the neat and clear picture that emerges from Figure 1 becomes shrouded in fog once we look at other cases of very rapid growth of GDP per capita. In Figure 2a through 2h we show charts similar to that of Figure 1. The striking fact is that not a single one of these other cases is characterized by the same clear negative correlation that we see in Figure 1.

Let me state the puzzle this way. The Japanese experience registered in Figure 1 exactly mirrors the intuition of most economists -- that growing productivity is normally or typically reflected in a reduction in the real price of foreign currency. Yet the other Figures do not confirm that conclusion. What we must do is reach an understanding-- a full appreciation -- of why this is so.

II. Resolving the Puzzle: Tradables vs. Nontradables

Let me begin this section by noting that much of the theoretical literature on real exchange rates defines the RER as the ratio P_t/P_h, the price of tradables divided by the price of home goods (nontradables). We shall see later that this is not the most useful definition for hands-on measurement of the RER, but it has the merit of being conceptually very clear and unambiguous. So I will proceed for the moment on the basis of this definition.

The key to the puzzle of the previous section is that Japan's period of rapid growth was characterized by huge and continuous improvements in productivity in the tradable goods sector, combined with a near-stagnation of productivity in the home goods (nontradables) sector. In this era of huge growth Japan was in the process of mastering the technological intricacies of production in autos, cameras, hi-fis, other consumer electronic products, computers, copiers, etc., etc. Her share in the world export markets of all these products grew dramatically. In many of

them a Japanese logo came to be a symbol of high quality. But while this incredible transformation was taking place in the production of tradables, there was serious resistance to technological advances in the nontradables sector. This seems to have stemmed from socio-political pressures. In urban areas, the interests of small shopkeepers were defended by the placement of innumerable bureaucratic and legal obstacles in the path of supermarkets and other modern distribution chains. In the rural areas, the small rice and vegetable farmers were the protected parties. Notoriously, rice in Japan has until very recently sold for as much as three times the world market price. For all practical purposes, protectionist measures insulated the farmers from international competition, thus effectively shifting most of Japan's agricultural production from the tradable to the home goods sector. Most agricultural products are by their nature tradable, thus making their internal prices a function of the world prices of corresponding products. But protectionist measures, when strong enough, can break this dependency, and cause the internal prices to depend solely or mainly on the forces of internal supply and internal demand. This is what is meant by high protection shifting a product from the tradable to the home goods sector.

So what is the likely scenario that was played out in Japan from the 1960s through the 1980s? Consider the world prices of tradables to be determined in world markets. Japan cannot influence them (significantly). Now insert very major improvements in total factor productivity in the tradables sector. One possible outcome of this might be that tradables output increases by λ percent per year, while the price of tradables falls by λ percent. This is compatible with the same factors being employed in the sector, the increase in output stemming from the greater productivity of the same labor and capital inputs.

It so happens that this is precisely the new equilibrium generated by what I call the Cobb-Douglas case. Formally this case would be characterized by a Cobb-Douglas utility function governing the distribution of final demand between tradables and home goods, and by Cobb-Douglas production functions governing the production processes within each of these sectors. But the exposition of the following sectors will not be formal. It will instead build in a convenient property of Cobb-Douglas functions -- namely that under competitive conditions a Cobb-Douglas utility function gives rise to demand functions in which the share of total spending allocated to each final product is constant. Similarly, a Cobb-Douglas production function leads to demands for productive factors such that under competitive conditions each productive factor (in the given sector) receives a constant share of the total outlays on that sector's product.

III. The Cobb-Douglas Case: Productivity Increase in Tradables Production

The Cobb-Douglas case lends itself readily to a relatively simple exposition. I therefore present it first, in order to acquaint readers with the main lines of the analysis. What distinguishes the Cobb-Douglas case is the simplicity of the demand relations that emerge from it. A Cobb-Douglas utility function will lead to demand functions in which constant fractions of income (α_t,α_h) are spent on the products of the tradables and home goods sectors respectively. Cobb-Douglas production functions, in turn, will lead to constant fractions $(\beta_\ell,\beta_k,\gamma_\ell,\gamma_k)$ of total receipts in each sector being paid to the labor and capital factors employed in that sector.

Our analysis will take the installed capital stock of each sector to be constant over the period considered. This locates out analysis in the short-to-middle run, which is particularly appropriate when we are concerned with movements of the real exchange rate over periods less than, say, a decade. Thus we have labor as the variable factor of production. In a standard

situation, the natural assumption is that the labor market is in equilibrium, both before and after the change being analyzed. This means that a single wage rate w must equilibrate the labor market.

Consider first the case (shown in detail in Table 1) of a productivity improvement in the tradable goods sector. This will lead to a shift of the supply function of that sector's output, since the same resources are capable of producing more output. A point on the supply curve specifying that 300 of output is offered at a price of 1.0 will transmute (after a 10% productivity charge, and holding the wage rate constant) into a point where 330 of output is offered at a price of 0.91. Total receipts will be the same as before, enabling the factors to receive the same payments as before. Moreover, at this new point, the required relationship $(w = MPL \times p_t)$ between the wage of labor and the value of its marginal product would be preserved, for wages would be the same, while marginal physical product would have risen by 10%, while the price of the product would have fallen by 10%.

It turns out that this transmutation of the initial equilibrium point is indeed the new equilibrium in the Cobb-Douglas case. Here we take the wages of labor to be the numeraire. Labor gets 2/3 of the 300 of output of the tradables sector, and 1/2 of the 200 of output of the home goods sector. Hence labor's total receipts are 300, while the fixed factor capital gets 200. With nominal wages remaining the same, and a fixed total supply of labor, the total wages bill (300) will be the same before and after the productivity change, as will the total national income (500) in nominal terms.

In these circumstances there is no reason for the equilibrium of the home goods sector to change. Total spending on home goods is still 200; the wage rate hasn't changed, so the same

price of 1.0 that equilibrated that market initially will continue to do so after the productivity change.

In this case the productivity change has been reflected in an increased output and a reduced price of the products of the tradables sector. These are the only changes, and they imply a reduction in the nominal exchange rate E from 1.0 to 0.91. The world price of tradables p_t^* is taken to be fixed at 1.0, but the real price of the dollar falls so as to bring the internal price of tradables to 0.91.

Table 1embodies all the assumptions set out above. The Cobb-Douglas assumptions imply that labor in the tradables sector will receive $\alpha_t\beta_\ell$ of total spending while labor in the home goods sector receives $\alpha_h\gamma_\ell$ of total spending. Labor as a whole thus receives a constant fraction $(\alpha_t\beta_\ell+\alpha_h\gamma_\ell)$ of total spending. That fraction is equal to 60% in the example of Table 1. But we are holding the wage rate constant (as the numeraire of our exercise). So total wage payments in nominal terms are the same (300) before and after the productivity improvement. The constancy of labor's share implies that total spending must be the same (500) both before and after the change in productivity. This, in turn, means that total spending on home goods remains the same (200) in nominal terms. Since the nominal wage rate is the same, nothing has occurred that will alter the home goods equilibrium price (p_h) remains at 1.0 and quantity (q_h) remains at 200.

The big change takes place in the tradable goods sector, as a consequence of the productivity improvements there. Product price (p_t) declines from 1.0 to 0.91, and quantity rises from 300 to 330. The particular variable that changes in order to bring about the drop in p_t is E, the nominal exchange rate. The underlying assumption here is that trade is balanced both

before and after the productivity improvement. Since wages are the numeraire and this is a full-equilibrium analysis, we must have a flexible exchange rate to bring about the balancing of trade. This is how E, the nominal exchange rate, becomes the instrument "validating", in a sense, the fall in p_t from 1.0 to 0.91.

In this case, then, the price level of home goods remains constant, while that of tradables falls to 0.91. The relative price of tradables thus declines. If we measure the real exchange rate by the formula $E\bar{p}_t^* / \bar{p}_d$, we have that on this definition also the real exchange rate declines. E falls from 1.0 to 0.91, $\bar{p}^*$ (the world price of tradables) stays constant at 1.0, and the general price level $\bar{p}_d$ (= $0.6\, p_t + 0.4 p_h$) falls from 1.0 to 0.946. Thus $E\bar{p}^* / \bar{p}_d$ falls from 1.0 to 0.962 (= .91/.946).

IV. The Cobb-Douglas Case: Productivity Increase in Home Goods Production

Table 2 deals with the "opposite" situation of a productivity increase in home goods production. Otherwise the assumptions are the same as those underlying Table 1. Once again, these assumptions determine that nominal income will remain constant at 500, and that total spending will be divided 300 on tradables and 200 on home goods. Once again wages are the numeraire. Labor in the tradable goods sector earns the same total amount as before, and the wage rate is the same, so total labor used in producing tradables is the same. This means that total output q_t of tradables is the same, and that the competitive price p_t of tradables will also be the same. This in turn implies that the equilibrium nominal exchange rate E will be the same, since $p_t = E\bar{p}^*$.

Thus everything in the tradables sector remains the same, both before and after the productivity change. This means the same amount of resources will be used in <u>each</u> of the two sectors, before and after the change. With the same amount of resources, the output of home

goods will go up by the percentage (here 10%) of productivity change. In Table 2 this means from 200 to 220. Correspondingly, since total spending stays the same, the price of home goods (p_h) must fall from 1.0 to 0.91.

Hence, when the productivity increase takes place in the home goods sector the real exchange rate defined as p_t/p_n rises from 1.0 to 1.10. Under the "empirical" definition of $E\bar{p}^*/\bar{p}_d$, the real exchange rate rises from 1.0 to 1.037.

V. Productivity Increase in Tradables Under Conditions of Surplus Labor (Nominal Wage Constant)

Here we proceed under the same Cobb-Douglas assumption as before, but postulating that the productivity increase takes place under initial conditions of Keynesian-type unemployment. A brief background discussion will help readers see how this case fits in.

The current Argentine crisis provides a good backdrop. In Argentina, the rate of unemployment has averaged around 15% for more than 6 years, and is now close to 20%. Most serious economists have diagnosed this unemployment as a result of the real exchange rate's failure to properly adjust to its equilibrium level. All signs point to a need for a devaluation in real terms. With a fixed exchange rate strongly mandated under its convertibility law, and for rather good historical reasons that I have discussed in earlier papers, successive Argentine governments have refused to contemplate a devaluation of the nominal exchange rate. Thus the natural way for the economy to move toward a devalued real exchange rate is for internal prices and costs (especially wages) to adjust downward in nominal terms. Using the real exchange rate definition RER = $E\bar{p}^*/\bar{p}_d$, one can see that if adjustment cannot take place by E moving upward, it has to occur (if it happens at all) by $\bar{p}_d$ moving downward. One can observe that clear deflationary pressures have been at work in Argentina all through the past 6 years, but they

have had only a minor effect on wages in the general price level. Economists attribute this to the rigidity of nominal wages, which resist adjustment in the downward direction.

So the Argentine authorities, recognizing the need for a real devaluation to bring the real exchange rate into equilibrium, have often looked to productivity increases as an alternative to either devaluation or deflation. They are thinking, of course, that productivity increase could modify the equilibrium RER, making it appreciate in real terms and thus bringing it closer to the rate we actually observe, maybe even converting the actual rate into an equilibrium one.

Our analysis of Sections III and IV shows that their wish will be granted only about half the time if the underlying conditions are similar to what we assumed there. Under these circumstances, a productivity improvement in the tradables sector would move the equilibrium RER downward, bringing it closer to the actual real rate in Argentina, and thus helping to solve the problem. An improvement in productivity in the home goods sector, however, would work in the opposite direction, moving the equilibrium RER upward, and making even larger the gap that has to be bridged in order to bring the economy into equilibrium.

This result, however, comes from a modeling of the economy under conditions of full employment, so it is perfectly legitimate to ask whether a similar result would arise under conditions of widespread unemployment.

This is where the analysis of this and the next section comes in. We here make the standard assumption in many Keynesian-type models -- that the nominal wage w is rigid. The evidence suggests that this assumption is fairly close to reality when the pressure in the labor market is downward -- viz., what actually has occurred in Argentina over the past 6 years. The assumption is probably less close to reality under conditions where, starting from a situation of high unemployment, the demand for labor increases significantly. In such circumstances what

we tend to see is wage rises hitting just one component, then another, then another, of the labor market. This makes the present modeling of the economy into an extreme case, but we shall see that this is actually helpful in that it reinforces the general conclusions to which we will come.

In what follows we retain all the basic assumptions of Sections III and IV, except that of full employment. We keep the wage constant at 1.0 -- but now not as a numeraire but rather as a "behavior function" -- an infinitely elastic supply curve of labor at the given nominal wage. We do need a variable to play the role of a numeraire, however, and we have chosen that to be the nominal exchange rate. This fits perfectly the Argentine case, and it is a highly plausible way of capturing the process of monetary expansion that has to occur if employment and output increase under Keynesian conditions.

When under these conditions a productivity increase occurs in the tradables sector, the first observation to be made is that the same resources that formerly produced 300 of output at a price of 1.0 can now produce 330 of output at a price of 0.91. This latter point (330, 0.91) is thereby a point on a new shifted supply curve of output of tradables. Call this point A. It is on the new supply curve, but it is not an equilibrium point, because unit costs are 0.91 while the product price is 1.0 (world price of 1.0 translated by a nominal exchange rate of 1.0). It turns out that with a Cobb-Douglas production function in which labor's share is two thirds, the supply curve of output of tradables will reach the price of 1.0 at an output of 372.

We now calibrate the new demand position on this basis. Spending on tradables should, under our demand assumptions, represent 60% of total spending, so total spending should be 620 (= 372 ÷ 0.6). Hence spending on home goods should equal 248. This will entail a move outward along the "old" supply curve of home goods (as no productivity change has occurred here). With a Cobb-Douglas production function that in this case has labor's share equal to one

half, the new equilibrium level of total receipts will represent an increase of quantity to 2.12 and of price to 1.17.

VI. Productivity Increase in Home Goods Under Conditions of Surplus Labor (Nominal Wage Constant)

Table 4 deals with the case of productivity increase in the home goods sector under conditions of widespread unemployment. The underlying assumptions are the same as those of Section V, except that we here change the sector in which the productivity increase is assumed to take place.

Our Cobb-Douglas assumptions make this a particularly easy case to deal with. The place to begin is the tradables sector. Here there is no reason whatever for production to change. The world price of tradables $\bar{p}^*$ is given, and the nominal exchange rate E is fixed, so the local currency price of tradables p_t stays constant at 1.0. This is the price that producers of tradables see and respond to. But it doesn't change, and neither does the wage rate w. So the previous production point ($q_t = 300$) will again be the equilibrium point. The condition of balanced trade means that supply of tradables and demand for tradables must be equal. This means that spending on tradables must equal 300. But our Cobb-Douglas assumptions mean that spending on tradables will be 60% of the spending so total spending must be 500. This in turn implies that spending on home goods must remain constant at 200. So the only real change that occurs as a consequence of the productivity increase is that the price of home goods falls to 0.91 and their quantity rises from 200 to 220. Table 4 is an exact replica of Table 2. The shift from the assumption of full employment to the assumption of surplus labor has not modified at all the new equilibrium that will emerge after a productivity improvement in home goods production.

So our conclusion from the analysis of Sections V and VI is that the relationship between productivity increases and the real exchange rate is much the same when we start from

Keynesian (surplus labor) assumptions as when we use neoclassical (full employment) assumptions. Productivity improvement in the tradable goods sector causes the real price of the dollar to fall, while productivity improvement in the home goods sector causes it to rise. Put in the context of the Argentine problem outlined at the beginning of Section V, the Argentine authorities should become aware that productivity improvement will only help narrow the gap between the actual real exchange rate and its equilibrium level to the extent that these improvements take place in the tradables sector. Productivity improvements in the home goods sector will add to the output of the economy and increase the real wage rate, but they will at the same time move the equilibrium real exchange rate even farther from the actual one, and in that sense will exacerbate the problem of real exchange rate adjustment with which the Argentine economy must cope.

VII. Making Our Analysis More General

The most convenient way to generalize the above analysis is to simply change the assumptions concerning final demand. In particular, the fractions of total spending that are spent on the products of the two sectors can change as between the old equilibrium and the new, rather than remaining constant as the Cobb-Douglas case requires.

In the full employment case we have that the same productive resources are in use, before and after the productivity change. The price of tradables falls, producing a genuine positive income effect for demanders of tradable goods. In moving from the previous equilibrium to the new one, demanders are moving along a demand curve for tradables that incorporates this income effect. In the Cobb-Douglas case, this demand curve has an elasticity of -1.0. This is what determines that the same quantity of resources will be devoted to tradables production, before and after the productivity increase. If this elasticity is greater than one (say, -1.2) more

resources will be devoted to tradables production after the change than before, and the price of tradables may fall from 1.0 to 0.93 (say), instead of to 0.91. If this happens, resources will be drawn from the home goods sector, and the price of home goods will fall (say) to 0.98 instead of staying at 1.0.

If the elasticity of demand for tradables is less than one (say -0.8), the reverse adjustment occurs. Now resources move from the tradables sector to that of home goods, and the price of tradables might end up at 0.89 (instead of 0.91) in the new equilibrium, while the price of home goods might go up to 1.02 or 1.03 instead of remaining constant at 1.0.

In this case (demand elasticity less than one) the real exchange rate falls by more than in the Cobb-Douglas case. When the demand elasticity is greater than one, it falls by less than in the Cobb-Douglas case.

Readers may wonder whether in the extreme, the real exchange rate might not fall at all as a consequence of a productivity improvement in the tradables sector. The answer is that such an outcome is not really possible. A demand elasticity greater than one clearly implies a downward sloping demand curve (inclusive of the income effect). Moving from lesser to greater quantities along this demand curve, the relative price of tradables must fall. Thus guarantees that the counterintuitive??? outcome (of a rise in productivity in the tradables sector causing p_t/p_h to increase) will not in fact occur.

When the productivity improvement is in the nontradables sector the analysis is exactly similar. The Cobb-Douglas case implies an own-price elasticity of demand for home goods equal to -1.0. This is what keeps resource use the same, before and after the productivity improvement. Modifying this elasticity up or down, we have resource use in the home goods sector either increasing or decreasing as a consequence of the productivity improvement. If

resource use decreases, this only makes p_h fall by more, producing an even greater increase in the real exchange rate. If resource use in the nontradables increases as a consequence of the productivity improvement, the rise of the real exchange rate will be less than in the Cobb-Douglas case. But under conditions of full employment the relative price of home goods must fall when the productivity rise is exclusive, in that sector. So our general conclusions concerning the effects of productivity improvements do not change as we modify our demand assumptions. Productivity improvement in the tradable causes the real equilibrium price of the dollar to fall; productivity improvement in the home goods sector causes it to rise.

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The above analysis can serve as a starting point as we consider situations of a Keynesian type -- with large pools of excess labor. Here one can say the adjustment would be just like the full employment case if total employment did not change as a consequence of the productivity improvement. The situation underlying Table 4 shows that this is indeed a plausible result in the case of a productivity improvement in the home goods sector. In this case, modifying the assumptions about demand elasticities could cause either more total resources (elasticity of demand for home goods greater than one) or less total resources (elasticity less than one) to be employed as a consequence of the productivity increase. The equilibrium of tradables production will in this case always be the same, because the wage rate, the exchange rate, and through it the internal price of tradables p_t all remain the same as before the productivity increase. So an improvement in productivity in home goods production will cause total employment to go up (elasticity greater than one), down (elasticity less than one) or remain the same (elasticity equal to one) depending on the elasticity of home goods demand.

With respect to productivity increases in the tradables sector, the production equilibrium shown in Table 3 does not depend on the demand elasticity for tradables. It comes from the intersection of a shifted supply curve of tradables with a constant internal??? price (p_t) guaranteed by our assumptions. If the shares in which spending is divided between tradables and home goods, remain the same as before the productivity increase, we get the results shown in Table 3. If the share of tradables spending increases, equilibrium will be reached with a smaller rise in home goods output than we see in Table 3. If this share decreases, the new equilibrium will entail a greater increase in home goods output than is shown in Table 3.

VIII. Conclusions

I hope that this paper helps readers to see more clearly the way in which productivity increases exercise their effect on output, prices, and the real exchange rate. The main purpose has been to show that one should not expect real exchange rate appreciation as a natural consequence of an increasing GDP per capita. This expectation is correct so long as the productivity increases are predominantly in the tradables sector, but one gets exactly the opposite result when the productivity increases take place in the home goods sector.

The example of Figure 1 (Japan) dramatically represents the case of productivity increases concentrated in the tradables sector. But all the other cases shown in Figures 2a through 2h reveal that the Japanese case is not representative of situations of rapid growth of per capita GDP. These latter cases show that one should not "expect" real exchange rate appreciation as a consequence of rapid output growth. This will happen to the extent that productivity increases are heavily concentrated in the tradables, but the Figures show that one should not bet heavily that this will in fact be the case in a given instance.

TABLE 1

Productivity Increase of 10% In Tradable Goods Production:

Full Employment Case

	Before Productivity Increase	After Productivity Increase
Spending on Tradables ($q_t p_t$)	300	300
Production of Tradables q_t	300	330
Price of Tradables p_t	1.0	0.91
Spending in Home Goods ($g_h p_h$)	200	200
Production of Home Goods q_h	200	200
Price of Home Goods p_h	1.0	1.0
Wage Rate (Numeraire)	1.0	1.0
Price Level $.6p_t + .4p_h = \bar{p}_d$	1.0	0.946
Real Wage $w/\bar{p}_d$	1.0	1.057
Marginal Product of Labor		
In Tradables Sector = w/p_t	1.0	1.10
In Home Goods Sector = w/p_h	1.0	1.0
Quantity of Labor		
In Tradables Sector L_t	200	200
In Home Goods Sector L_h	100	100
Quantity of Capital (Fixed Factor)		
In Tradables Sector K_t	100	100
In Home Goods Sector K_h	100	100
World Price of Tradables ($\bar{p}^*$)	1.0	1.0
Nominal Exchange Rate (E)	1.0	0.91
Real Exchange Rate Index		
Defined as p_t/p_h	1.0	0.91
Defined as $E\bar{p}^*/\bar{p}_d$	1.0	0.962

TABLE 2

Productivity Increase of 10% In Home Goods Production:

Full Employment Case

	Before Productivity Increase	After Productivity Increase
Spending on Tradables ($q_t p_t$)	300	300
Production of Tradables q_t	300	300
Price of Tradables p_t	1.0	1.0
Spending in Home Goods ($g_h p_h$)	200	200
Production of Home Goods q_h	200	220
Price of Home Goods p_h	1.0	0.91
Wage Rate (Numeraire)	1.0	1.0
Price Level $.6p_t + .4p_h = \bar{p}_d$	1.0	0.964
Real Wage $w/\bar{p}_d$	1.0	1.037
Marginal Product of Labor		
In Tradables Sector = w/p_t	1.0	1.0
In Home Goods Sector = w/p_h	1.0	1.10
Quantity of Labor		
In Tradables Sector L_t	200	200
In Home Goods Sector L_h	100	100
Quantity of Capital (Fixed Factor)		
In Tradables Sector K_t	100	100
In Home Goods Sector K_h	100	100
World Price of Tradables ($\bar{p}^*$)	1.0	1.0
Nominal Exchange Rate (E)	1.0	1.0
Real Exchange Rate Index		
Defined as p_t/p_h	1.0	1.10
Defined as $E\bar{p}^*/\bar{p}_d$	1.0	1.037

TABLE 3

Productivity Increase of 10% in Tradable Goods Production:

Keynesian Case

	Before Productivity Increase	After Productivity Increase
Spending on Tradables ($q_t p_t$)	300	372
Quantity q_t	300	372
Price p_t	1.0	1.0
Spending on Home Goods $q_h p_h$	200	248
Quantity q_h	200	212
Price p_h	1.0	1.17
Wage Rate (w)	1.0	1.0
Price Level ($.6p_t + .4p_h = \bar{p}_d$)	1.0	1.068
Real Wage $w/\bar{p}_d$	1.0	0.936
Marginal Product of Labor		
In Tradables Sector = w/p_t	1.0	1.0
In Home Goods Sector = w/p_h	1.0	0.855
Quantity of Labor		
In Tradables Sector L_t	200	248
In Home Goods Sector L_h	100	124
Quantity of Capital (Fixed Factor)		
In Tradables Sector K_t	100	100
In Home Goods Sector K_h	100	100
World Price of Tradables $\bar{p}^*$	1.0	1.0
Nominal Exchange Rate E	1.0	1.0
Real Exchange Rate Index		
Defined as p_t/p_h	1.0	0.855
Defined as $E\bar{p}^*/\bar{p}_d$	1.0	0.936

TABLE 4

Productivity Increase of 10% in Home Goods Production

Keynesian Case

	Before Productivity Increase	After Productivity Increase
Spending on Tradables ($q_t p_t$)	300	300
Quantity q_t	300	300
Price p_t	1.0	1.0
Spending on Home Goods $q_h p_h$	200	200
Quantity q_h	200	220
Price p_h	1.0	0.91
Wage Rate (w)	1.0	1.0
Price Level ($.6p_t + .4p_h = \bar{p}_d$)	1.0	0.964
Real Wage $w/\bar{p}_d$	1.0	1.037
Marginal Product of Labor		
In Tradables Sector = w/p_t	1.0	1.0
In Home Goods Sector = w/p_h	1.0	1.10
Quantity of Labor		
In Tradables Sector L_t	200	200
In Home Goods Sector L_h	100	100
Quantity of Capital (Fixed Factor)		
In Tradables Sector K_t	100	100
In Home Goods Sector K_h	100	100
World Price of Tradables $\bar{p}^*$	1.0	1.0
Nominal Exchange Rate E	1.0	1.0
Real Exchange Rate Index		
Defined as p_t/p_h	1.0	1.10
Defined as $E\bar{p}^*/\bar{p}_d$	1.0	1.037