"A NOTE ON THE REAL EXCHANGE RATE EFFECT OF GERMAN UNIFICATION"

by

Charles WYPLOSZ*

N° 90/65/EP/

* Professor of Economics, INSEAD, Boulevard de Constance, Fontainebleau, 77305 Cedex, France.

Printed at INSEAD,
Fontainebleau, France.

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Charles Wyplosz

DELTA (Ecole des Hautes Etudes en Sciences Sociales),
INSEAD and CEPR

August 1990

I thank Harmen Lehment for many insightful comments on a first version of this paper written while visiting the Kiel Institute of World Economics.

Abstract

It is often believed that the German Economic and Monetary Unification will result in an appreciation of the DM. This conclusion is reached when attention is exclusively directed to the demand side. In this note, it is shown that supply side considerations imply a permanent fall in per capita wealth in Germany. This implies a long real depreciation, mirroring partly a worsened net asset position (as Germany borrows abroad to finance capital accumulation), and partly increased output of German goods. While the short run effect is ambiguous, a real depreciation is shown to be possible, and the conditions for it to happen are spelled out.

1. Introduction

There is a general presumption that the German Economic and Monetary Unification (GEMU) will lead to an appreciation of the DM (see e.g. Burda (1990), Lehment (1990), Siebert (1990)). The reasoning seems to be that the combination of higher spending from new free and eager consumers, increased public spending as subsidies rise to smooth the transition in the East, and possibly a tight monetary policy stance to contain inflationary pressure, all combine to rising interest rates and therefore an exchange rate appreciation. Such a view focuses on the demand side of GEMU, both the surge in private spending and the policy mix response.

Yet, there is another way of looking at the situation, which allows for supply side considerations as well. The DM zone used to consist of the highly productive area called the Federal Republic. At a stroke of a pen, on July 1, 1990, this zone has been expanded to include a highly unproductive area, the Democratic Republic. Intuitively, at least part of the value of a currency should reflect the strength of the underlying economy. In this respect, the new DM zone resulting from the GEMU, temporarily at least, cannot fail to be weaker than the old DM zone, since it is now the (weighted) average of the FRG and the GDR. Could this imply a DM depreciation? Since this effect is temporary, expected to last until eastern productivity rises to western levels, is the exchange rate only affected temporarily?

This note is intended to provide a framework to deal with such questions. Of course, part of a currency's status is also related to the conduct of monetary policy. It is therefore useful to separate two aspects of the exchange rate. The *real* exchange rate corresponds to the first argument, and is presumably driven by real factors, chiefly relative productivity or competitiveness. The *nominal* exchange rate is set so as to achieve a given real rate, given the nominal factors, chiefly monetary policy. Here,

the focus is entirely on the real aspects. The focus here is entirely on real considerations and the model is accordingly set to explain the real exchange rate. Leaving out monetary considerations is of course an important limitation to be kept in mind. The next section presents the model, a two-good version of the standard infinitevely lived representative consumer model. Section 3 characterizes the GEMU as the overtaking by West Germany of a land with no initial capital stock but a labor force identical to its own. The optimal path that follows is analyzed and key results are derived. In particular, it is found that the real exchange rate always depreciates in the new steady state. In the short run, the direction of the exchange rate change is ambiguous, as a decline is private consumption leads to an excess supply of the domestically produced good, while reduced per capita output and enhanced investment outlays push in the opposite direction. While the utility function used throughout is general, the results of Section 3 relies on a particular assumption. Section 4 makes a different assumption and explores its implications. Section 5 concludes.

2. Before GEMU

2.1. The model

It is obvious that two key effects will dominate the German landscape: the need to bring East Germany up to western capital standards and the knowledge of all Germans that real income will grow over time in the east. A central issue is how the consumption-saving decisions incorporate these two features. This is why the chosen model emphasizes capital accumulation and inter-temporal choices. As the focus of inquiry is the real exchange rate, we consider a two-good one country model[1]. We start

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[1] An extension should include two countries, the FDR and the GDR, vis a vis the rest of the world. Such an extension would be

laying out the model in total real magnitudes (capital letters), then turn it into real per capita variables (lower case). Domestic residents consume both locally produced goods (C) and imports (C*). The relative price is $\lambda=EP^*/P$, where E is the domestic price of foreign currency. Domestic firms, owned by domestic residents face adjustment costs as they invest. As in Hayashi's (1982) formulation, part of the spending on investment is lost in adjustment costs which are increasing and convex in the amount of investment. Thus the difference between investment spending I and actual capital accumulation $\dot{K} = dK/dt$ is the cost of adjustment $\phi(\dot{K})$:

$$(1) \qquad \dot{K} = I - \phi(\dot{K}), \qquad \phi(0)=0,\ \phi'\geq 0,\ \phi''>0.$$

Residents can borrow and lend abroad. If we define B as real net asset holdings, the country's budget constraint is:

$$(2) \qquad \dot{B} = r\,B + Y(K,\ L) - C - \lambda\,C^* - I$$

where r is the real interest rate (in terms of home goods[2]) and Y(K, L) the production function, assumed to be homogeneous of degree one. Together (1) and (2) imply:

$$(3) \qquad \dot{B} = r\,B + Y(K,\ L) - C - \lambda\,C^* - \dot{K} - \phi(\dot{K})$$

To complete the model, we need a market clearing conditions for the domestically produced good (the country being small the

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helpful in focusing attention to relative wages.

[2] In principle we should have $r = r^* + (\dot{\lambda}/\lambda)$, where r^* is the world real rate of interest. This would complicate the analysis considerably, yet probably not altering most of the substantive conclusions.

foreign good market equilibrium condition is irrelevant):

$$(4) \qquad Y(K, L) = C + \dot{K} + \phi(\dot{K}) + X(\lambda)$$

where $X(\lambda)$, $X'>0$, is the export function. Implicit in (4) is the assumption that all investment spending falls on the domestically produced good.[3]

There is no population growth nor technological progress in this model. Normalizing all variables by the size of the DM-zone population (or labor force) L, (3) and (4) become:

$$(3') \qquad \dot{b} = rb + y(k) - c - \lambda c^* - \dot{k} - \phi(\dot{k})$$

$$(4') \qquad y(k) = c + \dot{k} + \phi(\dot{k}) + \alpha x(\lambda)$$

where $\alpha = L^*/L$ is a measure of the size of the country, the inverse of the ratio of its population L to the world population L^*, and $x = X/L^*$ is per capita foreign spending on domestic goods.

The budget constraint is completed by the transversality condition $\lim \int e^{-\delta t} b(t)dt = 0$. Later on, for simplicity, we will assume that initially the country's net asset position is zero.

2.2. Optimal behavior

We assume that the representative infinitely-lived domestic resident chooses a consumption-investment plan so as to maximize:

$$(5) \qquad \int_t^{\infty} u[c(s),c^*(s)]\, e^{-\delta(s-t)}\, ds$$

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[3] Alternatively, all investment could fall on imported goods. This does not change qualitatively the results as is noted below in context.

subject to the budget constraint (3'). The instantaneous utility function $u(c,c^*)$ is assumed to satisfy the usual property that it is quasi-concave. Letting $z = \dot{k}$, the Hamiltonian is:

$$\mathcal{H} = u(c,c^*) + \mu\,[rb + y(k) - c - \lambda c^* - z - \phi(z)] + q\mu z$$

where μ and q are, respectively, the shadow price of foreign assets and capital accumulation, q being measured in units of μ. The first order conditions are:

(6) $$u_c = \mu \qquad\qquad u_{c^*} = \lambda\mu$$

(7) $$q = 1 + \phi'(\dot{k})$$

(8) $$\dot{\mu} = \mu\,(\delta - r)$$

(9) $$\mu\dot{q} + q\dot{\mu} = \mu\,[\delta q - y'(k)]$$

As is usual the existence of a steady state requires the additional assumption $\delta=r$[4]. This implies that μ is constant. Then (9) simplifies to:

(9') $$\dot{q} = \delta q - y'(k)$$

2.3. Solution

The model can be easily solved graphically due to its block-recursiveness. Note that (7) and (9) can be used first to determine q and k independently of the other variables. Their evolution is shown on Figure 1. The system is saddle-path stable.

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4 For a detailed presentation of this class of models, see Blanchard and Fischer (1989). A way to avoid the assumption $\delta=r$ is to use a Uzawa (1968) utility function which declines with wealth. An example in the open economy context is Obstfeld (1980).

Next, we eliminate c* in (6) to obtain[5]:

$$(10) \qquad H(\lambda,\ c,\ \mu) = 0 \qquad\qquad H_\lambda \le 0,\ H_c \le 0,\ H_\mu \ge 0$$

Both the inequality conditions in (10) and the downward slope of the schedule HH, which describes (10) in Figure 2, depend upon the assumption that $u_{cc*}>0$. Then, given μ, optimal behavior implies a negative link between the real exchange rate and consumption of the domestic good.[6] The case $u_{cc*}\le 0$ is taken up in Section 4.

The good market equilibrium condition (4') implies another relationship between c and λ, parameterized by k, $\dot{k}$ and α:

$$(11)\ G(\lambda,\ c;\ k,\ \dot{k},\ \alpha) = 0 \qquad G_\lambda \ge 0,\ G_c \ge 0,\ G_k \le 0,\ G_{\dot{k}} \ge 0,\ G_\alpha \ge 0.$$

This relationship, for given values of k, $\dot{k}$ and α, is represented by the GG schedule in Figure 2. A priori, we do not know which of the two schedules is steeper. While we describe in Figure 2 one case, we consider both possibilities in Section 3.

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[5] To see this, fully differentiate (6):

$u_{cc}\ dc + u_{cc*}\ dc^* = d\mu$, and $u_{cc*}\ dc + u_{c*c*}\ dc^* = \lambda\ d\mu + \mu\ d\lambda$

Eliminating dc*, we obtain:

$$\mu\ u_{cc*}\ d\lambda + \left[\ u_{cc}u_{c*c*}-(u_{cc*})^2\ \right] dc + \left[\ \lambda u_{cc*} - u_{c*c*}\ \right] d\mu = 0$$

The quasi-concavity of the utility function implies that the first bracketed expression is non-negative. For the second one to be non-positive, we need $u_{cc*}<0$ and large in absolute value.

[6] An increase in λ reduces c* which then lowers $\mu=u_c$: to keep u_c constant, consumption of the domestic good c must fall.

The intersection of the GG and HH schedules determines the values of λ and c, conditional on k, $\dot{k}$, μ, and α. Since μ is constant, the HH schedule will remain unchanged within any regime. Thus HH describes the evolution of c and λ as the GG schedule moves when k and $\dot{k}$ change over time. An increase in k shifts GG up as a higher output level needs to be met by higher demand. An increase in $\dot{k}$ shifts GG down as investment crowds out exports - via a depreciation - and/or consumption spending.

2.4. Steady state

The steady state values of q and K are:

(12) $$\bar{q} = 1 + \phi'(0)$$

(13) $$y'(\bar{k}) = \delta\ \bar{q}$$

Note that the steady state stock of capital is entirely determined by the rate of time preference and the slope of the cost of investment function at the origin. Without any loss of generality, we can assume $\phi'(0)=0$, so that $\bar{q}=1$ and $y'(\bar{k})=\delta$.

In steady state, with $k=\bar{k}$ and $\dot{k}=0$, the schedule G()=0, noted $\bar{G}\bar{G}$, depends only upon α. The steady state is then fully characterized by the value of μ, the marginal utility of home good consumption,which determines the HH schedule. It is given by the budget constraint along with the transversality condition. If A denotes total real spending (in terms on the domestic good):

(14) $$A = c + \lambda c^*$$

Solving (6) for c and c*, we obtain[7]:

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[7] Differentiating (6), we have:

(14') $$A = A(\lambda, \mu) \qquad A_\lambda \gtreqless 0,\ A_\mu < 0$$

In what follows we assume that $A_\lambda = 0$, which gives the plausible result that consumption smoothing implies constant total real spending. Indeed, if we integrate the budget constraint condition (3') rewritten as:

(3") $$\dot{b} = rb + y(k) - A(\lambda, \mu) - \dot{k} - \phi(\dot{k})$$

we find:

(15) $$\int_0^\infty A(\mu)\, e^{-rt} dt = (b_0 + w_0)$$

where real wealth is:

(16) $$w_0 = \int_0^\infty [y(k) - \dot{k} - \phi(\dot{k})]\ e^{-rt} dt.$$

Since μ is constant, we finally get:

(17) $$A(\mu) = r\ (b_0 + w_0)$$

which implicitly determines μ.[8]

$$dA = -\Delta^{-1}\ (\mu u_{c^*c^*} - \lambda\mu u_{cc} - \Delta c^*)\ d\lambda + \Delta^{-1}\ (\lambda^2 u_{cc} - 2\lambda u_{cc^*} + u_{cc^*})\ d\mu$$

where $\Delta = u_{cc} u_{c^*c^*} - (u_{cc^*})^2 \geq 0$ since u() is quasi-concave. The second order condition requires that the expression in the second brackets be non-positive, but the expression in the first brackets is of indeterminate sign.

[8] If $A_\lambda \neq 0$, the value of μ depends on the whole expected path of λ and A is not constant.

2.5. Trade balance

The trade balance is:

(18) $$TB = \alpha\, x(\lambda) - \lambda\, c^*$$

Using the condition $u_c=\mu$ in (6), we have:

(19) $$TB = T(\lambda,\ c;\ \alpha,\ \mu) \quad T_\lambda > 0,\quad T_c < 0,\quad T_\alpha > 0,\quad T_\mu < 0$$

The condition $T_\lambda>0$ obtains under the assumption that $\alpha x'-c^*>0$, which is akin to the Marshall-Lerner condition[9]. Thus, in Figure 2, the equilibrium trade balance condition is shown as the upward sloping TB=0 schedule. Trade is balanced initially if we assume no net asset position ($b_0=0$) since in steady state the current account $\dot{b}$ is in equilibrium.

3. A stylized GEMU

The model can be used to describe a particular case of GEMU. It is assumed that the GDR is taken over by the FRG, so that western and eastern citizens and firms become indistinguishable.[10] More realistically perhaps, it is assumed that the eastern part contributes no capital to the GEMU, simply bringing in labor. As a result, L increases to L'. Initially, this has the effect of reducing the capital-labor ratio k from K/L to K/L'. This is not a permanent effect since we know from (13) that in steady state k in the GEMU will revert to the pre-GEMU Federal Republic's $\bar{k}$.[11] The

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[9] Differentiating (18) and $u_c=\mu$, we obtain:

$$dTB = (\alpha x'-c^*)\, d\lambda + (\lambda u_{cc}/u_{cc^*})\, dc + x\, d\alpha - (\lambda/u_{cc^*})\, d\mu$$

[10] This is not meant to be realistic... As mentioned earlier, a desirable extension would include two different countries in the GEMU.

[11] Remember that there is no population growth and no technological

only permanent effect comes from the change in the parameter α which declines from L^*/L to L^*/L'. If world per capita demand for German goods $x(\lambda)$ remains unchanged - and why should it change? - this implies that German exports *per German worker* will decline.

The evolution of q and K remains driven by Figure 1 and is shown in Figure 3: per capita capital falls and then gradually increases back to its steady state level. This affects the GG schedule temporarily only. In the long run, $\bar{G}\bar{G}$ shifts upward (see Figure 4) as the decline in per German capita exports $\alpha x(\lambda)$ requires a real depreciation and/or higher domestic consumption to restore good market equilibrium.

The HH schedule shifts permanently if the marginal utility μ is different in the post-GEMU era. From (16) we know that per capita wealth declines because, *during the transition*, y(k) is lower than in the pre-GEMU steady state while investment spending further reduces net per capita income. Then (17) implies that total real spending falls as soon as the GEMU comes into existence and will remain lower forever. The condition $A_\mu<0$ in turn implies a higher marginal utility $\bar{\mu}>\mu$. Under the assumption that $u_{cc^*}>0$, this implies a once and for all downward shift of the HH schedule, to the position $\bar{H}\bar{H}$ in Figure 4.

The two possible outcomes with $u_{cc^*}>0$ are shown in the two panels of Figure 4. The initial pre-GEMU position is represented by point A, the new steady state by point C. If GG is steeper, we have a long run real appreciation, while we obtain a long run real depreciation in the opposite case. Fortunately, we can rule out the former. To do so, we consider the current account at the time (t=0) of the creation of the GEMU. (3") and (17) imply:

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progress. Removing this assumption will not alter the results which follow.

$$\dot{b}(t) = rb(t) + [y(k) - \dot{k} - \dot{\phi}(k)] - r\int_t^{\infty} [y(k) - \dot{k} - \dot{\phi}(k)]e^{-r(s-t)}ds$$

The dynamics of k in Figure 3 implies that, anytime after the GEMU, net income $y^n=y(k)-\dot{k}-\dot{\phi}(k)$ is such that $y^n(t')>y^n(t)\ \forall\ t'>t$. With $b_0=0$, we find that initially the current account $\dot{b}(0)$is in deficit. Faced with a temporary fall in net income, German consumers borrow abroad to smooth out spending. In the final steady state, though, the trade balance must be in surplus to service the accumulated debt $\bar{b}$. However, the trade balance equation (19) implies that as α falls and μ rise permanently, the post-GEMU trade balance schedule $\bar{T}\bar{B}=0$ shifts upward. As points below $\bar{T}\bar{B}=0$ indicate a trade deficit, in the first panel Germany undergoes ever increasing deficits and never settles at a zero current account.[12] Thus the first panel is not an acceptable solution. In the second panel, on the contrary, steady state point C lies above the $\bar{T}\bar{B}=0$ schedule, indicating a steady state trade surplus equal to $r\bar{b}$.

Thus we find that in the steady state there is a real depreciation. With investment back to zero and per capita output back to the pre-GEMU level, the permanent fall in spending A implies an excess supply of home goods. This effect is reinforced by reduced per German capita exports. Good market equilibrium therefore requires exports to make up the difference. The fall in total spending also translates in a fall in imports λc^* which generates the trade balance surplus required to service the

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12 The interpretation is as follows. The condition for GG to be steeper than HH is $1/\alpha x'>[u_{cc}u_{c^*c^*}-(u_{cc^*})^2]/\mu u_{cc^*}$, which occurs for a small price elasticity of exports. Then Germany may compensate for its permanent income loss by exploiting a terms of trade advantage through a real appreciation. If it were feasible, it would already have done before GEMU. It could not because it would imply permanent current account deficits.

accumulated external debt.

The dynamics following the GEMU is further illustrated in the second panel of Figure 4. On impact, with k reduced and investment positive, the GG schedule lies below its steady state position $\bar{G}\bar{G}$. When the GEMU is created, we therefore move to a point like B_1 or B_2. As net output falls, good market equilibrium (4') requires a fall in consumption and exports. A smaller α helps, and consumption falls. There is no presumption whether this is more than enough and the real exchange rate depreciates (B_1), or whether a real appreciation is required to crowd out exports (B_2). Over time, as net output rises (both because k increases and investment falls), a continuous real depreciation is needed to crowd in exports and maintain good market equilibrium. In the process, the trade balance improves and eventually turns into a surplus, while consumption of the home good falls as a result of the income effect of the depreciation.[13]

4. An alternative scenario

In this section we consider the case $u_{cc^*} \leq 0$. If $u_{cc^*} < 0$, the trade balance schedule is downward sloping while the HH schedule is upward sloping as $H_\lambda < 0$ and $H_c > 0$, but the sign of H_μ is ambiguous. Figure 5 shows two possibilities. In the first panel, we assume $H_\mu > 0$ so that the permanent increase in μ shifts the HH schedule up and to the left. The result is a long run depreciation at point C. The dynamics is similar to that of the previous section with two exceptions. First, in the long run, consumption c of home goods may be higher than in the pre-GEMU state. Second, during the adjustment phase, c rises unambiguously. In this case, the adverse income effect of the depreciation is smaller than the substitution effect, away from imported goods into home goods.[14] In the second

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[13] Remember that $A = c + \lambda c^*$ is constant throughout.

[14] The behavior of the now downward sloping trade balance schedule is ambiguous. The rise of μ tends to shift it downward while the

panel, we consider the case where u_{cc*} is negative and large enough in absolute value to imply $H_\mu<0$. Then, it is unclear whether in the long run the real exchange rate appreciates or depreciates. In the short run, it is likely to appreciate however. Consumption of home goods also increases, both on impact and during the transition. A large absolute value for u_{cc*} implies that imports fall disproportionately, so that total spending, while reduced, requires an increase in spending on home goods. The resulting excess demand requires an appreciation.

Finally, the case where $u_{cc*}=0$ is simplest. The HH schedule is vertical and shifts leftward when wealth and total spending fall ($H_\mu>0$ and μ rises). So c remains constant after an initial decrease and so does spending on imports λc^*. The outcome is otherwise qualitatively similar to the case $u_{cc*}>0$ discussed in Section 3.

5. Conclusion

The stylized description of the GEMU presented here departs from previous work by focusing on both supply conditions and intertemporal considerations. Working with a general utility function, we find that in general, the GEMU implies a long run real depreciation. In the short run, the situation is ambiguous, but during the transition the real exchange rate always depreciates. The general intuition should be clear. For a number of years, much more resources in the new DM-zone will be devoted to building up the capital stock in its eastern part. Therefore, income net of investment will always be lower than what it used to be in the old DM-zone, eventually reverting back to its initial level (this abstracts of course from the trend increase due to technological progress). The combination of a lower per capita

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fall in α pushes it downward. Assuming that it does not move much, it is clear that we have an early deficit followed by a surplus.

wealth and of rising net income results in a permanently reduced level of spending and initial borrowing, thus early trade deficits and a build up of foreign debt. With per capita output back to its initial pre-GEMU level and reduced spending, good market equilibrium requires that exports be crowded in, hence the long run depreciation. There is a possibility, shown in Section 4, of a long run real depreciation. Its mere description suggests that it is more a curiosity than a likely outcome.

An additional reason for real depreciation, both in the short and in the long run, is the fall in *German* per capita exports. Indeed, if foreigners do not develop an enhanced taste for German goods, per foreign capita exports should remain unchanged, therefore reduced per German worker. Here again, a depreciation is required to sell the larger total output that the new DM zone will produce.[15]

To conclude, three considerations are worth raising. First, how big are these effects likely to be? The fall in α is proportional to the increase in the population in the DM-zone and inversely proportional to the value of pre-GEMU East-German exports on world markets. Population increases by about 25% and East-German exports are quite limited. So the α-effect cannot be dismissed as trivial. The other effect at work is the fall in per capita wealth. It is entirely the consequence of lower per capita net (of investment) income, since in the long run there is no reason to anticipate a fall in productivity. Initial per capita output (at world market prices) falls by somewhat less than 25% (the per capita effect), say 15% to be on the conservative side. Estimates are that the build up of capital will require some ten years and that the capital/GNP ratio is about 4. This requires about 40% of GDR's GNP

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15 It is easy to check that none of the qualitative results depend on the α-effect. If α were to remain roughly unchanged, the new long run equilibrium would occur at the intersection of the new HH and the old GG schedules. It simply makes an early ream appreciation more likely.

per year on a linear buildup, i.e. some 10% of the FRG's GNP to achieve the same per capita capital stock.

In discounted terms, after ten years, the shortfall is 24% of 1990 FDR GNP for the per capita export effect, and 86% for the investment effect.[16] Thus per capita wealth falls by the equivalent of one year of FRG GNP, implying a permanent reduction of spending of some 5.5% of GNP, not a trivial number either. Of course, a notable part of this effect will be cushioned by foreign borrowing and will appear as a permanent worsening of Germany's net external position.

The second remark concerns other possible adverse effects. Clearly, the model implicitly assumes full employment of existing capacities. Obviously, unemployment will rise considerably in the East during the transition. A complete analysis would require extending the model to a two-country set-up, allowing for different productivities, wages, and prices in the two parts which constitute the new DM-zone. Presumably, such a model would point out the role of various assumptions regarding the behavior of prices and wages in the East. It would also darken somewhat the picture as far as net output is concerned.

Finally, brighter prospects are likely to arise as the result of possible increasing returns to scale. Two sources of such gains

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[16] If it takes ten year to bring up the per capita GNP of the new DM-zone from 85% of the FRG's 1990 level y_0, the per capita GNP is $y(t)=y_0(0.85+0.015\ t)$ for t=0, 10. The shortfall is $s(t)=y_0-y(t)$. In present value $S=\sum s(t)\ R^t$. With R=0.95, assuming a 5% real interest rate (a high discount factor), we find $S=0.24\ y_0$. For investment, assume that k rises linearly from 0% to 400% of East Germany's GNP y^e over 10 years, this means an annual rate of investment $i = 0.4\ y^e = 0.4\ (y^e/y_0)\ y_0 = 0.1\ y_0$. The present value over 10 years is $I=\sum iR^t=0.86\ y_0$. The total wealth effect is $S+I=1.1\ y_0$. The fall in permanent spending is dA=r dw, or $0.055\ y_0$ with r=0.05.

are likely. First, German corporations may not have reached yet their maximum efficiency size because of the various barriers to trade which lie behind the EC Single Market proposal. A unified Germany opens up scopes for a speed-up of this process.[17] The second major source of increasing returns may come from technology transfers and endogenous growth effects, as recently stressed by Romer (1986).

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[17] It is noteworthy that in several industries, European firms are smaller than their US and Japanese counterparts, which operate on larger domestic markets.

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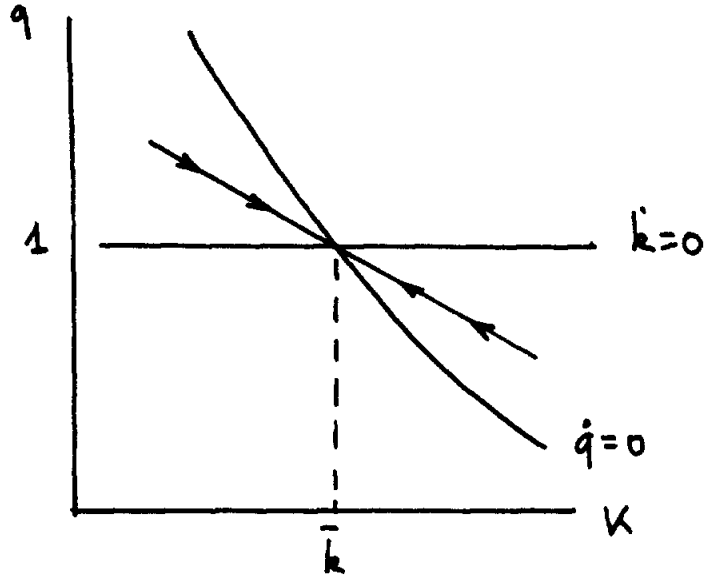


Figure 1

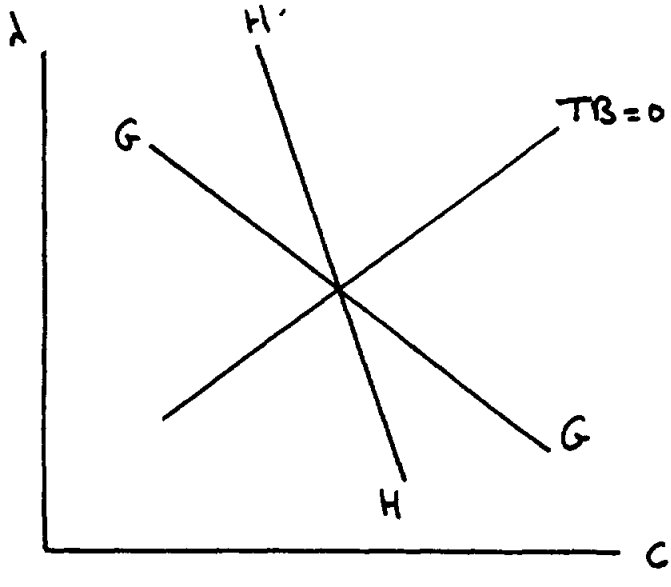


Figure 2

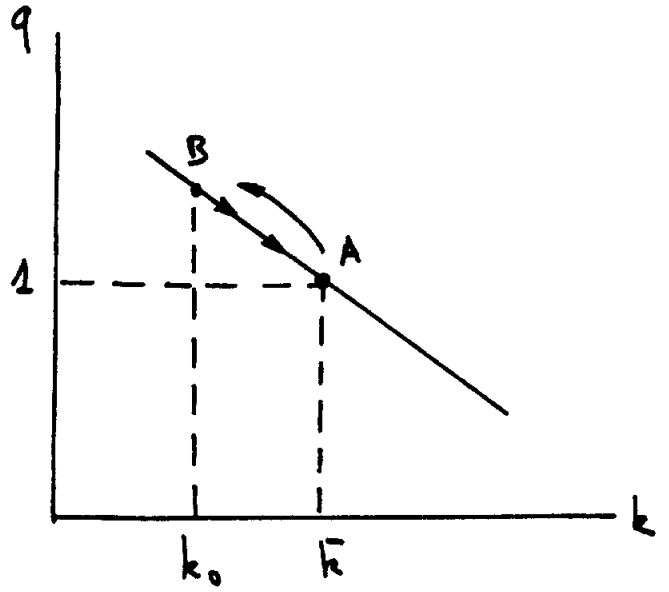


Figure 3

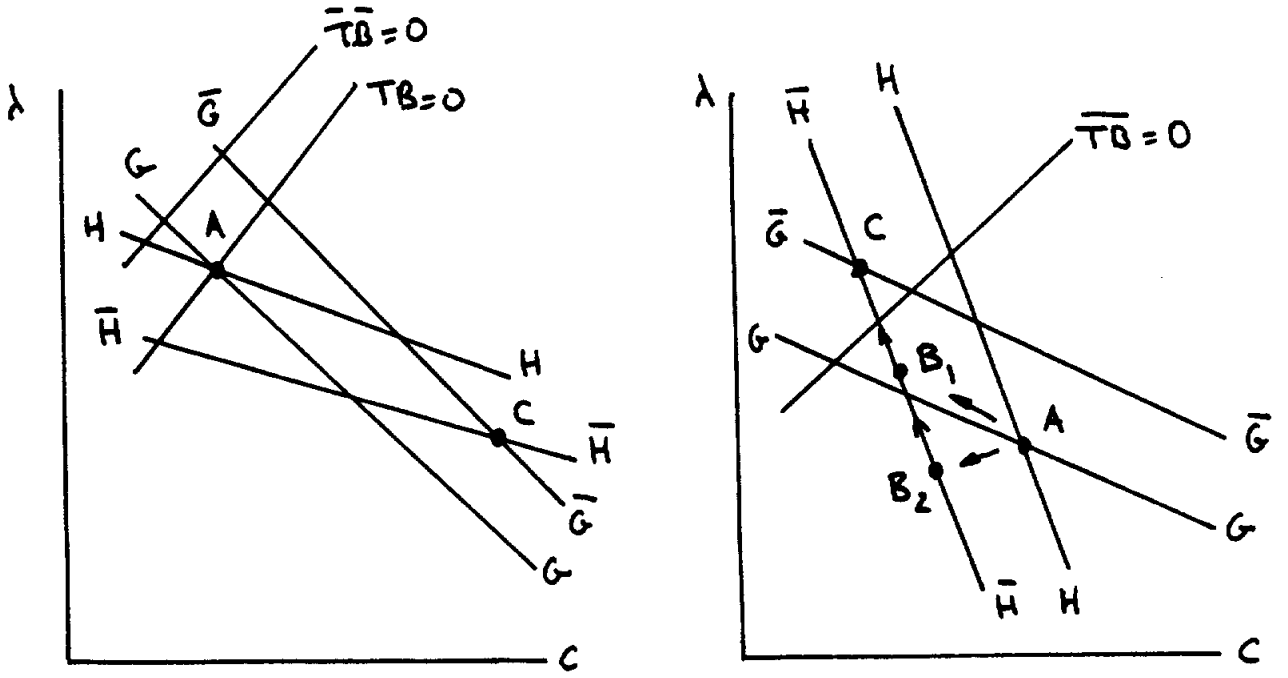
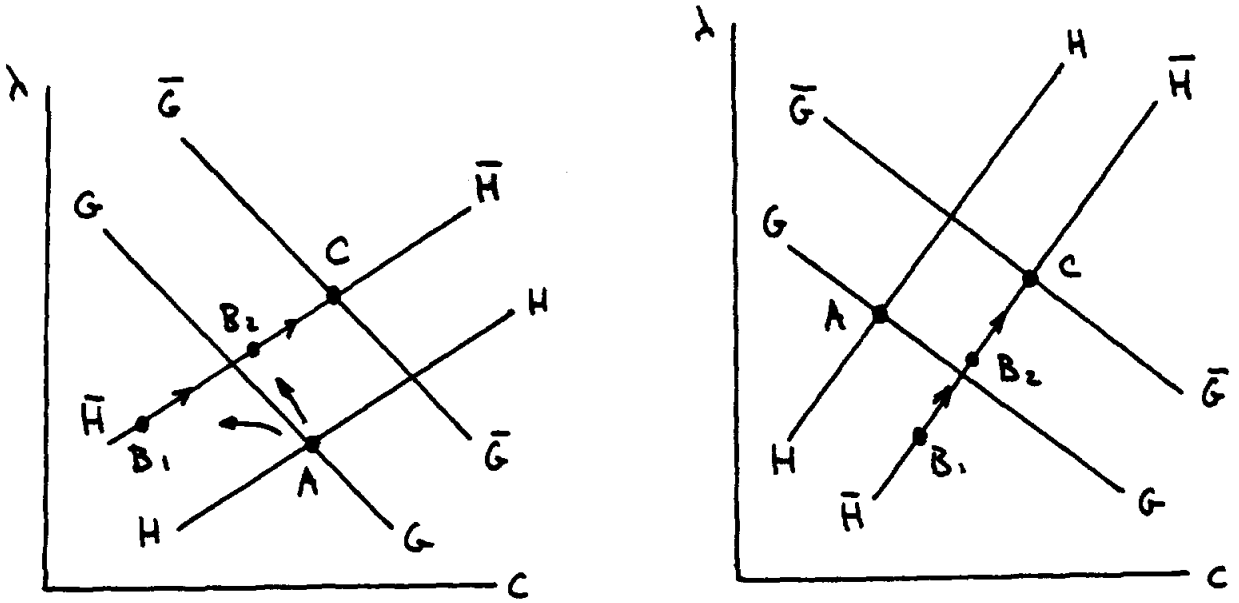


Figure 4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$\bar{G}$
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Figure 5

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