Dynamic Effects of Offshoring

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Abstract

We analyze the effects of offshoring in a multisector-growth-model where the sectors differ by TFP-growth. Our results imply that offshoring influences the long run growth rate of the economy along different channels and that the growth effects depend on the development of terms of trade and on whether low-productivity-growth-activities or high-productivity-growth-activities are offshored. Negative growth effects can arise provided that some dependencies exist between countries. Furthermore, offshoring has an impact on structural change. It can slow down or accelerate the structural change patterns of the economy that offshores depending on the development of terms of trade.

Keywords: offshoring, structural change, growth

JEL Classification Numbers: F16, F43, O4

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In the last years, offshoring[1] has been one of the most prominent terms in political debate in industrialized economies, appearing regularly on the political agenda in the USA (e.g. during the election campaigns of democrats) and in western Europe (in discussion about offshoring to the "new" EU-member countries in the eastern Europe). This is not surprising, since the rapid progress in information and communication technologies, the emergence of new countries in international trade (China, India,…) and the advances in regional integration (e.g. a growing European Union) create continually new potential for offshoring. As a result, offshoring is "one of the most rapidly growing components of trade" (Grossman and Helpman (2005), p. 36) with the potential for being the "next industrial revolution" (Blinder (2007b).[2]

Hence, it is necessary to evaluate this new trend in order to provide some policy guidelines regarding the optimal reaction to it. The economic literature reacted to this necessity by introducing some new theoretical and empirical studies. An overview of these studies can be found for example in Garner (2004), Mankiw and Swagel (2006) and GAO (2005). This literature focuses mainly on the implications of offshoring for welfare and income distribution within static frameworks (e.g. Bhagwati et al. (2004) and Samuelson et al. (2004)) as well as for unemployment (e.g. Mitra and Ranjan (2007)). However, the *dynamic* effects of offshoring on the long run GDP-growth are a rather rarely researched topic[3], although the dynamic effects of offshoring via structural change[4] and via capital deepening which are neglected by static trade theory (e.g. by the models of Bhagwati et al. (2004)) might be more important than static effects (see Milberg et al. (2007), p. 7)).

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[1] Offshoring means here that firms shift activities abroad (to unaffiliated firms or to own affiliates).

[2] For estimates of offshoring potential see Blinder (2007a), Jensen and Kletzer (2006) and Van Welsum and Vickery (2005).

[3] One reason for this asymmetry in the research efforts is probably (beside of the fact that offshoring is a relatively new research topic) that topics such as unemployment are most prominent in the political debate, since they are associated with fears in the public awareness.

[4] Structural change means here reallocation of labor across sectors such as manufacturing, services and agriculture during the development process.

In fact we do not know anything precise about the effects of offshoring on GDP-growth: There is some empirical literature on the productivity growth effects of offshoring at the industry and plant level, e.g. Amiti and Wei (2005, 2006), Mann (2004) and Girma and Gorg (2004). (A further overview of the literature can be found in Olsen (2006).) However, no clear patterns as to how offshoring affects productivity can be concluded from this literature (see Olsen (2006), p. 28). Furthermore, going beyond the firm level, some effects on productivity growth may arise which are still not researched in detail: As noted by Blinder (2005, 2007b) offshoring of high-productivity-growth-activities (that became possible by progress in information and communication technologies) could lead to a growth slowdown in the economy that offshores, if the redundant factors are reallocated to sectors with lower productivity growth (according to the framework of Baumol's (1967) "cost disease"). The findings by Fixler and Siegel (1999) imply that (domestic) *outsourcing* has impacts on sector-productivity and on structural change in a framework similar to that by Baumol (1967) (i.e. in a framework where productivity growth differs across sectors). Therefore, one can expect that *offshoring* (or international outsourcing) has similar effects, as well. All these results imply that it might be important to analyze the effects of offshoring in a framework where sectors differ by TFP-growth in order to study the effects of offshoring on structural change and GDP-growth.

This is exactly what we do: we model an economy where the sectors differ by TFP-growth. (Evidence for the different TFP-growth rates across sectors has been presented by Baumol et al. (1985).) A part of the intermediate inputs production is taken over by the foreign country, i.e. offshoring takes place. Our framework is based on the model presented by Ngai and Pissarides (2007), i.e. we do not rely on a trade model but work with a growth model. (An overview of trade models dealing with offshoring can be found in Baldwin and Robert-Nicoud (2007).)

Our results imply that there are two channels along which offshoring influences the growth rate of aggregate output: (1) Offshoring influences the (implicit) total-factor-productivity-growth of intermediates-production. This effect implies that offshoring acts like a kind of technological progress in intermediates-production by integrating the foreign cost-advantages into domestic production (provided that terms of trade develop favorably in the long run). (2) These productivity-changes in the intermediates-production have an additional indirect effect on the aggregate growth as well: they influence the rate of capital-accumulation. This effect is similar to the one mentioned by David Ricardo (1815) who argues that international trade can lead to an increase in profit margins and thus to more investment and more income growth (see e.g. Milberg et al. (2006), pp. 6 and 7).

Both effects point in the same direction. Whether these effects are positive or negative depends on the development of the terms of trade and on whether high-productivity-growth (hpg) activities or low-productivity-growth (lpg) activities are offshored: Offshoring of lpg activities can increase the growth rate of the economy even when the terms of trade worsen in the long run. However, offshoring of hpg activities can increase the growth rate of the economy only if the terms of trade improve in the long run. The reason for this fact is that lpg activities feature increasing prices due to "Baumol's cost disease". Thus, even when the terms of trade worsen in the long run it can be "cheaper" importing intermediates rather than producing them at home.

These results imply that services offshoring may be less likely to increase the long run growth rate of industrialized economies in the future, because (1) it is argued in the literature that services offshoring may include high-productivity-growth-activities in the future (see e.g. Blinder (2007a) for estimations with respect to this fact) and (2) it is also argued in the literature that offshoring might have a negative effect on terms of trade in industrialized economies (see e.g. Samuelson (2004) and Rodriguez-Clare (2007)). Both arguments imply that services offshoring will include high-productivity-growth-activities and a worsening of terms of trade. As explained above, our model implies that offshoring does not increase the long run growth rate of the economy under such conditions.

If some dependencies arise (i.e. if some of the foreign intermediate inputs become essential for the domestic production) offshoring can also have negative growth effects within our model. As we will explain, such dependencies may arise due to dependency on natural resources or if the economy does not research in some technologies due to international specialization. In this case, the negative growth-effects of unfavorable terms of trade development cannot be avoided completely by reducing the extent of offshoring, since the substitution of foreign intermediates by domestic products is associated with costs (because the foreign inputs are essential for production).

Our results imply that structural change patterns are slowed down in the long run if terms of trade develop favorably (i.e. if offshoring is productivity-enhancing at the macro-level), and vice versa. The reason for this fact is that the productivity-growth-increase is associated with more investment (due to the “Ricardian effect” mentioned above). That is, investment gains on relative importance as part of domestic output which implies that consumption loses on relative importance as part of domestic output. This leads to structural change smoothing, since structural change is caused only by consumption demand patterns in the long run equilibrium. Thus, our results imply that the offshoring-induced growth-slowdown mentioned by Blinder (2005, 2007b) cannot happen in this case, since the structural change patterns which cause this growth-slowdown are smoothened. (Such a slow-down happens only if terms of trade develop unfavorably.) Furthermore, these results imply that *offshoring* can have different effects in comparison to domestic *outsourcing*: While our results imply that *offshoring* can lead to a structural change slowdown, the results by Fixler and Siegel (1999) imply that domestic *outsourcing* leads to an acceleration of structural change.

Last but not least, our results imply that indeed the economy that offshores must first go through a turbulent phase before reaching the phase where structural-change-smoothing occurs and potentially higher growth rates are achieved (see above). During the turbulent phase strong reallocations across sectors (and thus, probably high unemployment) will happen, in order to adapt the production-structures to the effects of offshoring (in detail: there are changes in exports, investment and demand for domestic intermediates). All these reallocations lead to a “manufacturing-sector renaissance” in our model, if offshoring is productivity enhancing. That is, the manufacturing employment share (that is normally decreasing) increases during this phase due to increased exports and capital demand. This result may explain the fact that offshoring is not associated with higher unemployment in this sector in empirical studies (e.g. by Amiti and Wei (2005)).

The rest of the paper is set up as follows: In the next section (section 1) we present the model assumptions. Then we calculate the model-optimum and equilibrium (section 2). Subsequently, we analyze the effects of offshoring on growth (section 3) and structural change (section 4). In section 5 we discuss some further interesting implications of the model, i.e. the distribution of effects across phases, implications for unemployment, “manufacturing renaissance” and “partial offshoring”. In section 6 we present an application of the model to services offshoring. Finally, we summarize our main results and suggest some topics for further research (section 7).

1. Model Assumptions

The model is a kind of disaggregated Ramsey-model with international trade. Due to model-setting there exists an aggregate balanced growth path that features balanced growth with respect to aggregates, but unbalanced growth (i.e. structural change) with respect to disaggregated variables (for details see also Ngai and Pissarides (2007)). We assume that there are three types of goods and services ($i = M, P, I$). However, the model could be extended for an arbitrary number of goods. The representative household can consume all three types of goods and services. We assume the lifetime utility function suggested by Ngai and Pissarides (2007). They have proven that the lifetime utility (U) has to be a logarithmic function of the consumption composite in order to allow for aggregate balanced growth. The consumption composite itself is a CES-function of consumption (C_i) of goods and services ($i = M, P, I$):

(1) $$U = \int_0^\infty \ln\left[\left(\sum_i \omega_i C_i^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}\right] e^{-\rho t} dt, \qquad i = M, P, I$$

(2) $$0 < \varepsilon < 1; \quad \rho, \omega_i > 0 \quad \forall i$$

(3) $$\sum_i \omega_i = 1$$

where t is the time index.

Since we assume here $\varepsilon < 1$, the goods are poor substitutes and relative demand is price inelastic. (For further explanations with respect to the features of this utility function see Ngai and Pissarides (2007).) These goods and services are produced by the corresponding domestic sectors. Each sector produces its output via a Cobb-Douglas production function by using labor, capital and intermediate inputs. The amount of labor available is constant and normalized to unity. However, exogenous population growth could be integrated into this model easily. Total factor productivity (TFP) grows in each sector at a sector specific rate (g_i):

(4) $$Y_i = A_i n_i^{1-\alpha-\beta} (k_i K)^\alpha (z_i Z)^\beta, \qquad i = M, I, P$$

$$\alpha, \beta > 0 \text{ and } 1 - \alpha - \beta > 0$$

(5) $$\frac{\dot{A}_i}{A_i} = g_i, \qquad i = M, I, P$$

where Y_i is the output of sector i; K is the aggregate capital; Z is an index of the total "amount" of intermediate inputs; k_i, n_i and z_i represent respectively the fraction of capital, labor and intermediate inputs devoted to the production of sector i; A_i is a sector-specific productivity parameter.

Intermediate inputs are partly provided by (the domestic) sector I and partly provided by the foreign sector F (offshoring). That is, sectors M and P do not produce intermediate inputs. We assume that domestic and foreign intermediate inputs complement each other in the production of final goods. (This is consistent with empirical findings e.g. by Desai, Foley and Hines (2005) or Hanson, Mataloni and Slaughter (2003).) Thus, the intermediate inputs index (Z) is a Cobb-Douglas-function of domestic and foreign intermediate inputs:

(6) $$Z = h_I^{\varphi}(h_F)^{1-\varphi}, \quad 0 < \varphi < 1$$

h_I is the "amount" of domestic intermediate inputs and h_F is the "amount" of foreign intermediate inputs. It should be noted here that the assumption of Cobb-Douglas function implies that foreign intermediate inputs (h_F) cannot be *completely* substituted by the domestic intermediate inputs (h_I), i.e. h_F is an essential factor. The reason for this "limited" substitutability may be that some of the imported intermediate inputs cannot be produced at home but only abroad. Before offshoring became possible (i.e. during autarky), these inputs might not have been essential for production. However, because offshoring became possible, technological progress developed in such a manner that they became essential. We can think of three categories of reasons for this fact:

- *Natural resources and technological progress:* The home country does not posses some natural resources (e.g. petroleum). Furthermore, the climatic conditions might not be appropriate to produce some types of intermediates (e.g. solar energy). It might be the case that these natural resources cannot be substituted completely by domestic resources. Before offshoring became possible, these resources might not have been essential for production. However, because of globalization these foreign intermediate products became available and thus technological progress developed such that they became essential. An example might clarify this argumentation: In the beginning of the 20th century most European countries were not very dependant on petroleum. That is, in this time they were able to substitute the petroleum products by other products e.g. coal. However, due to technological progress (increasing use of gasoline engines and the increasing importance of chemical industry) petroleum products became an essential intermediate input for many of the modern industries. However, some of the industrialized countries do not posses relevant resources of crude oil at home. Thus, they are dependant to some degree on offshoring of intermediate-petroleum-products.

- *International specialization in trade and technological progress:* It is also possible that due to international specialization the foreign country develops some technologies over time that the domestic country does not develop (since the domestic country did not research in these areas due to specialization in other areas). These technologies might also be protected by international patents. Such technologies might also become essential in production similar to our example with petroleum.
- *Legislation:* At home, the use of some technologies and resources may be rejected on ethical grounds (e.g. genetical engineering) or due to environmental legislation (e.g. the cut-down of some types of trees may be prohibited).

On the other hand, equation (6) also implies that domestically-produced intermediate inputs are as well essential (in part). That is, not all intermediates can be produced abroad. Here the reason might be that, for example, some intermediate inputs require that their supplier is present at the production facilities at home, e.g. for repairing a factory building. Another example are the personal intermediate services mentioned by Blinder (2005, 2007a, 2007b), i.e. services that cannot be delivered from afar (via Internet).

Since the economy imports intermediate inputs, it has to “pay” for them by exporting goods and services. Let sector P represent all goods and services that cannot be exported. That is, only the output of sector M can be exported. Alternatively, we could also assume that sector-

P-output can be exported and sector-M-output cannot. However, the key-model results would be the same. (We assume here in accordance with the standard trade theory that the output of sector I is not exported, i.e. the foreign country has some comparative advantage in I-production. That is, we assume that goods and services that are exported are not imported at the same time. However, the model could be modified easily to include at the same time exports and imports of the same good.) We abstract from any other trade not associated with offshoring in order to isolate the effects of offshoring. Let e_M denote the exports of sector M. Furthermore, let p_i denote the price of good i ($i = M, I, P$). Thus, aggregate exports (*E*) are given by

(7) $$E := p_M e_M$$

We assume now that aggregate exports (E) are related to imports (h_F) in the following manner:

(8) $$E = T h_F$$

where T is the ratio of exports to imports associated with offshoring. It determines how much the economy has to export in order to get one unit of intermediates-imports (offshoring). Therefore, T is corresponding to the (reciprocal of) "offshoring-terms of trade". We assume that the offshoring-terms of trade is changing at a constant rate (g_T):

(9) $$\frac{\dot{T}}{T} = g_T$$

Capital (*K*) is produced only in sector M. (Therefore, this sector could also be interpreted as the manufacturing sector[5].) Capital depreciates at rate δ. Thus, overall, sector-M-output is consumed (C_M), exported and used as capital-input:

(10) $$Y_M = C_M + \dot{K} + \delta K + e_M$$

As explained above, the output of sector (I) is consumed (C_I) and used as intermediate input:

[5] For empirical evidence that the manufacturing sector produces nearly all investment goods see e.g. Kongsamut et al. (1997).

(11) $Y_I = C_I + h_I$

The output of sector P is consumed (C_P) only, as explained above:

(12) $Y_P = C_P$

We assume that capital, labor and intermediate inputs are mobile across sectors. All capital, labor and intermediate inputs have to be used in domestic production, thus

(13) $\sum_i k_i = 1 \quad i = M, I, P$

(14) $\sum_i n_i = 1 \quad i = M, I, P$

(15) $\sum_i z_i = 1 \quad i = M, I, P$

Furthermore, we define aggregate consumption expenditures (*C*) and aggregate output (*Y*) as follows:

(16) $C := \sum_i p_i C_i \quad i = M, I, P$

(17) $Y := \sum_i p_i Y_i \quad i = M, I, P$

We choose the output of sector M as numéraire, thus:

(18) $p_M = 1$

Overall, we should keep in mind that the domestic country imports intermediate inputs (that are substitutes for sector-I-output) and exports a part of the sector-M-output. There are no capital imports and no labor mobility across countries.

2. Optimum and Equilibrium

Now, the model is fully specified. Equations (1)-(18) can be optimized by using a Hamiltonian.[6] Then, after some algebra the following intertemporal and intratemporal

[6] The optimality conditions which are obtained by the Hamiltonian, provided that there is free mobility of labor across sectors, are (*u(.)* denotes the instantaneous utility function from equation (1), i.e. *u(.)=ln[…]*): $p_i = \frac{\partial u(.)/\partial C_i}{\partial u(.)/\partial C_M} = \frac{\partial Y_M / \partial(l_M L)}{\partial Y_i / \partial(l_i L)} = \frac{\partial Y_M / \partial(k_M K)}{\partial Y_i / \partial(k_i K)} = \frac{\partial Y_M / \partial(z_M Z)}{\partial Y_i / \partial(z_i Z)}, \forall i$; $p_I = \frac{\partial Y_M}{\partial(z_M Z)} \frac{\partial Z}{\partial h_I}$; $T = \frac{\partial Y_M}{\partial(z_M Z)} \frac{\partial Z}{\partial h_F}$;

optimality conditions can be obtained for our model (we subdivide the equations describing the optimal solution into aggregated and disaggregated level equations):

Aggregated level

(19) $Y = A_M K^{\frac{\alpha}{1-\beta}} \eta^{\frac{\beta}{1-\beta}}$

(20) $\dot{K} = (1-\beta)Y - C - \delta K$

(21) $\frac{\dot{C}}{C} = \alpha \frac{Y}{K} - \delta - \rho$

(22) $Z = K^{\frac{\alpha}{1-\beta}} \eta^{\frac{1}{1-\beta}}$

(23) $E = (1-\varphi)\beta Y$

where η is a function of exogenous model parameters growing at constant rate:

(24) $\eta = \beta A_I \varphi^{\varphi} (1-\varphi)^{1-\varphi} \left(\frac{p_I}{T} \right)^{1-\varphi}$

Disaggregated level

(25) $p_i = \frac{A_M}{A_i} \quad \forall i$

(26) $\frac{p_I h_I}{\varphi} = \frac{T h_F}{1-\varphi} = \beta Y$

(27) $n_i = k_i = z_i \quad \forall i$

(28) $\frac{p_i C_i}{C} = \frac{x_i}{X} \quad \forall i$

(29) $n_P = \frac{p_P Y_P}{Y} = \frac{x_P}{X} \frac{C}{Y}$

(30) $n_M = \frac{p_M Y_M}{Y} = \frac{x_M}{X} \frac{C}{Y} + \left(\delta + g^* \right) \frac{K}{Y} + (1-\varphi)\beta$

$-\frac{\dot{u}_M}{u_M} = \partial Y_M / \partial (k_M K) - \delta - \rho$; where $u_M = \partial u(.)/\partial C_M$.

(31) $$n_I = \frac{p_I Y_I}{Y} = \frac{x_I}{X}\frac{C}{Y} + \varphi\beta$$

where x_i and X are time varying auxiliary variables and functions of exogenous model parameters:

(32) $$x_i := \frac{p_i C_i}{C_M} = \left(\frac{\omega_i}{\omega_M}\right)^{\varepsilon}\left(\frac{A_M}{A_i}\right)^{1-\varepsilon} \quad \forall i$$

(33) $$X := C / C_M = \sum_i x_i$$

g^* denotes the equilibrium growth rate of aggregates in the equilibrium. (We will discuss this growth rate and all the equations later in detail.)

Now, following Ngai and Pissarides (2007), we define an **aggregate balanced growth path (ABGP)** such that aggregate consumption (*C*), aggregate output (*Y*) and capital (*K*) grow at the same rate, thus, being consistent with the Kaldor facts. This definition requires balanced growth with respect to aggregates. However, it allows for unbalanced growth with respect to disaggregated variables such as output shares, etc., i.e. structural change can take place. The equations describing the aggregate optimum (especially equations (19)-(21)) resemble the ones from the "normal" Ramsey-model in all relevant features. Thus, the model in aggregates behaves like a normal Ramsey model. Therefore, we now that a unique and saddle-path-stable ABGP exists in our model. It can be easily proven by using equation (19) that along this ABGP the constant equilibrium growth rate (g^*) of capital (*K*) and aggregate output (*Y*) is given by

(34) $$g^* = \frac{(1-\beta)g_M + \beta g_\eta}{1-\alpha-\beta}$$

where

(35) $$g_\eta := \frac{\dot{\eta}}{\eta} = g_I + (1-\varphi)\left(\frac{\dot{p}_I}{p_I} - g_T\right) = const.$$

Note that g_η can be interpreted as the implicit TFP-growth rate of the intermediates-production (Z). For detailed explanations, see APPENDIX A. $\dot{p}_I / p_I$ is given by equation (25).

Provided that *K* and *Y* grow at rate g^*, it follows from equations (20), (21) and (23) that aggregate consumption expenditures (*C*) and aggregate exports (*E*) grow at rate g^* as well. Overall we can summarize these results in the following Lemma:

Lemma 1: *Along the ABGP all aggregates (Y, K, C, E) grow at the constant rate* g^*.[7] *It can be seen from equations (27)-(33) that although aggregate variables grow at a constant rate structural change still takes place, i.e. the sectoral factor input shares, consumption shares and output shares change over time, because* x_i *and X are not constant along the ABGP.*

3. Effects of Offshoring on Growth of Aggregates

Up to now we modeled an economy that offshores intermediate inputs. The following Lemma implies how we can modify the model equations to describe an economy without offshoring:

Lemma 2: *The model describes an economy without offshoring if we set* $\varphi = 1$ *and* $e_M = 0$ *in all model equations. In this case we can see from equation (6) that only the output of sector I is used as intermediate input, i.e.*

(6a) $\quad Z = h_I$.

We can see from equations (34) and (35) that the economy that offshores $(\varphi < 1)$ features a higher growth rate than the economy that does not offshore $(\varphi = 1)$, provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$. So we can conclude:

[7] It follows from equation (22) that *Z* grows at a constant rate as well. However, its growth rate is different from g^*.

Lemma 3: *Offshoring leads to a higher growth rate of the economy (g^*) provided that the price of intermediate products that are produced at home (p_I) grows at higher rate than the price that has to be paid for importing offshored goods (T), i.e. $\frac{\dot{p}_I}{p_I} - g_T > 0$. (Note that $\frac{\dot{p}_I}{p_I}$ is a function of exogenous model parameters; see equation (25).) Otherwise, if $\frac{\dot{p}_I}{p_I} - g_T < 0$, offshoring leads to a lower growth rate of the economy (in comparison to the state without offshoring). In this case, the relative amount of offshoring (h_F / h_I) decreases (see equation (26)); nevertheless, the negative effect on the growth rate of the economy still remains. However, note that this negative outcome is based on the assumption that foreign intermediate imports become essential for domestic production (e.g. petroleum products; see detailed explanations on pages 8 and 9).*

Overall, Lemma 3 implies that offshoring can lead to negative growth effects only if two conditions are satisfied: (1) terms of trade develop unfavorably in the long run (i.e. $\frac{\dot{p}_I}{p_I} - g_T < 0$) and (2) intermediate inputs that can only be produced abroad become essential. In this case, the costs that are associated with unfavorable terms of trade development cannot be avoided completely by reducing the relative amount of offshoring (h_F / h_I). The reason for this fact is that the substitution of foreign products by domestic products is associated with costs (due to the assumption of Cobb-Douglas function in equation (6), i.e. both types of intermediates are essential and the isoquant is convex).

An interesting question within this model is why the growth rate of aggregate output (*Y)* changes due to offshoring: It follows from equation (19) that the growth rate of *Y* is determined as follows:

$$\text{(19a)} \quad \frac{\dot{Y}}{Y} = g_M + \frac{\alpha}{1-\beta}\frac{\dot{K}}{K} + \frac{\beta}{1-\beta} g_\eta .$$

Remember that we have shown in APPENDIX A that g_η can be interpreted as the TFP-growth-rate of intermediates-production (Z). Furthermore, note that Lemmas 1 and 3 imply that offshoring has an impact on $\dot{K}/K$ and on g_η (because of equation (35) and Lemma 2).

Both impacts are positive (negative) provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$ ($\frac{\dot{p}_I}{p_I} - g_T < 0$).

Thus, we can conclude that equation (19a) implies that offshoring influences the growth rate of aggregate output (Y) in two different ways: (1) it changes the rate of capital-accumulation and (2) it changes the growth-rate of implicit total-factor-productivity of Z-production.

Thus, our results imply that offshoring has effects going beyond the capital deepening effects mentioned by Milberg et al. (2006).

Definition 1: *High-productivity-growth-sectors are sectors where the TFP-growth-rate is higher than the TFP-growth-rate of the capital-producing sector (i.e.* $g_i > g_M$, $i \neq M$ *). Low-productivity-growth-sectors are sectors where the TFP-growth-rate is lower than the TFP-growth-rate of the capital-producing sector (i.e.* $g_i < g_M$, $i \neq M$ *).*

Equation (25) implies that high-productivity-growth-activities have decreasing prices, i.e. $\frac{\dot{p}_i}{p_i} < 0$ for $g_i > g_M$. This implies (because of equations (34) and (35) and Lemma 2):

Lemma 4: *Offshoring of high-productivity-growth-activities (* $g_I > g_M$ *) increases the growth rate of the economy (* g^* *) only if the terms of trade improve in the long run, i.e.* $g_T < 0$ *. On the other hand, offshoring of low-productivity-growth-activities (* $g_I < g_M$ *) can increase the growth rate* g^* *even when the terms of trade worsen in the long run, i.e.* $g_T > 0$ *(provided that* $\frac{\dot{p}_I}{p_I} - g_T > 0$ *).*

Overall, Lemma 4 implies that even when the terms of trade worsen in the long run, offshoring can increase the growth rate of GDP, provided that low-productivity-growth-activities are offshored. The reason for this fact is that these activities feature increasing prices due to the "cost disease" (see also Baumol (1967) and Ngai and Pissarides (2007)). Hence, even when the terms of trade worsen (price for foreign intermediates grows) it can be cheaper using foreign intermediates instead of domestic intermediates (provided that the price for domestic intermediates grows at higher rate than the price for foreign intermediates). Overall, for positive growth effects of offshoring it is not merely relevant whether the terms of trade improve or not, but rather how the terms of trade develop in comparison to the price of the domestic sector (I) that is competing with the foreign sector (Lemmas 3 and 4).

As explained in section 1, the standard structural change theory (e.g. Baumol (1967)) implies that offshoring of high-productivity-growth-activities might cause lower GDP-growth-rates in industrialized countries, if the factors that become redundant due to offshoring are reallocated to the sectors with lower productivity growth (due to price-inelastic demand); see also e.g. Blinder (2005, 2007b). In other words: Within Baumol's (1967) framework production factors are reallocated to lower-productivity-growth-sectors during structural change (provided that relative demand is price-inelastic), thus causing a productivity growth slowdown. Offshoring of high-productivity-growth-activities seems to accelerate this process (since it causes redundant factors in the high-productivity-growth-sectors that might be reallocated to the low-productivity-growth-sectors due to price-inelastic demand).

Our model implies that this effect might not come into force in the long run. As we will see in the next section, if $\frac{\dot{p}_I}{p_I} - g_T > 0$ (see also Lemma 3), structural change patterns that are implied by Baumol's (1967) framework are slowed down by offshoring. That is, less labor force is withdrawn from the high-productivity-growth-sectors over time. The reason for this fact is the following: The reallocation of factors to low-productivity-growth-sectors during structural change is caused by consumption demand patterns along the ABGP (price-inelastic demand). However, offshoring leads to a decrease in the importance of consumption demand patterns for structural change, since investment gains on importance as part of GDP, provided that offshoring is productivity enhancing (i.e. $\frac{\dot{p}_I}{p_I} - g_T > 0$).

On the other hand, if $\frac{\dot{p}_I}{p_I} - g_T < 0$ offshoring leads to the productivity-growth-slowdown that is implied by Baumol's (1967) framework (as mentioned by Blinder (2005, 2007b)).

4. The Effects of Offshoring on Structural Change

In this model structural change is caused by differences in TFP-growth across sectors. The differences in TFP-growth are reflected by prices (see equation (25)). The representative household responds to the changes in prices by changing the demand-ratios across goods. Hence, producers must adapt production to changing demand, which leads to factor reallocations across sectors, i.e. structural change. (For detailed discussion see Ngai and Pissarides (2007)). We analyze now how offshoring affects these structural change patterns.

Equations (29)-(31) are relevant for analyzing the effects of offshoring on structural change. They represent the sectoral employment shares when the economy offshores. Since labor is normalized to unity in our model, these equations also represent the sectoral employment. We compare now the structural change patterns in an economy that offshores with the structural change patterns in an economy that does not offshore (see Lemma 2). We assume in this section that offshoring is productivity enhancing in the long run, i.e. $\frac{\dot{p}_I}{p_I} - g_T > 0$. (The case that $\frac{\dot{p}_I}{p_I} - g_T < 0$ will be discussed briefly at the end of this section).

We have to differentiate between *"level effects"* and *"growth effects"* of offshoring with respect to structural change:

"Level effects" of offshoring: This term stands for the changes in shift parameters of the employment share curves (29)-(30). Note that the term "structural change" in general refers to *changes* in employment shares. Thus, in the long run (after the changes in the shift parameters have happened) shift parameters have no impact on structural change. Thus, "level effects" might be regarded as some transitional effects of offshoring with respect to structural change but not as the long run impacts of offshoring on structural change within our model. We have to distinguish between three different "level effects":

Effect 1: Offshoring increases the exports-to-output ratio (E/Y), since the economy has to "pay" for intermediate imports. *This effect increases the employment share of the exporting sector M* (see equation (30); note that E/Y is given by $(1-\varphi)\beta$ due to equation (23)). E/Y is constant along the ABGP due to Lemma 1. Thus the increase in exports is a transitional effect with respect to structural change (i.e. since E/Y is constant along the ABGP, it has no impact on the changes in the employment shares along the ABGP). Thus, exports have no impact on structural change in the long run.

Effect 2: Offshoring decreases the domestic-intermediates-production-to-output ratio $\left(\frac{p_I h_I}{Y}\right)$, since some intermediates are imported from abroad. (Note that $\frac{p_I h_I}{Y}$ is given by

$\varphi\beta$ in case of offshoring due to equation (26). In the case without offshoring, $\frac{p_I h_I}{Y}$ is given by β (see Lemma 2 and equation (26)). Thus, the domestic-intermediates-production-to-output ratio decreases by $(1-\varphi)\beta$ due to offshoring.) *This effect decreases the employment share of the intermediate-inputs-sector I* (via $\varphi\beta$; see equation (31)). Note again that this effect is transitional as well, since $\frac{p_I h_I}{Y}$ is constant in the long run (it is equal to $\varphi\beta$). That is, the decrease in the domestic-intermediates-production-to-output ratio has no effects on structural change in the long run.

Effect 3: It can be shown (see APPENDIX B) that the aggregate investment-to-output ratio ($(\delta + g^*)K/Y$) increases due to offshoring, provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$. *This effect increases the employment share of the capital-producing sector M* (see equation (30)). Since $(\delta + g^*)K/Y$ is constant along the ABGP (see Lemma 1), this effect is transitional, i.e. it has no impact on structural change in the long run. The increase in the aggregate investment-to-output ratio occurs, because of the higher aggregate productivity-growth in case of $\frac{\dot{p}_I}{p_I} - g_T > 0$ (see also the previous section).

Effect 4: The aggregate output of our economy is consumed, exported, used as capital-input and used as intermediate input (see equations (7), (10)-(12) and (16)-(17)). Thus, the following relation must be true: $1 = \frac{C}{Y} + \frac{(\delta + g^*)K}{Y} + \frac{E}{Y} + \frac{p_I h_I}{Y}$. Our explanations of Effects 1 and 2 imply that E/Y increases due to offshoring by the same amount as $\frac{p_I h_I}{Y}$ decreases due to offshoring. Thus, $\frac{C}{Y} + \frac{(\delta + g^*)K}{Y}$ must be constant when comparing the state without offshoring to the state with offshoring. This fact implies that the aggregate consumption-to-output ratio (C/Y) must decrease due to offshoring, provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$, since Effect 3 implies that $(\delta + g^*)K/Y$ increases due to offshoring, provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$. Note that, as just explained, the decrease in C/Y is caused only by the increase in the investment-to-output ratio ($(\delta + g^*)K/Y$) (and not by exports or by domestic intermediate goods production). What are the implications of the decrease in C/Y for structural change? Lemma 1 implies that C/Y is constant along the ABGP. However, x_i / X's are not constant along the ABGP (see equations (32)-(33)).[8] Thus, equations (29)-(31) imply that the decrease in C/Y leads to a decrease in the shift and slope parameters of all employment-share-curves. The decrease in *shift* parameters is a "level effect" (i.e. it has only transitional impacts on structural change, as explained above) which reduces the employment shares in all sectors. The decrease in *slope* parameters of the employment-share-curves is a "growth effect" of offshoring that we will discuss now.

"Growth effects" of offshoring: The term "growth effects" stands for the changes in slope parameters of the employment-share-curves associated with offshoring. Remember that only the slope of the employment-share-curves determines structural change along the ABGB (i.e. in the long run), since structural change is defined as *changes* in employment shares over time. Our discussion of Effects 1-4 above and equations (29)-(31) imply that $\frac{x_i}{X}\frac{C}{Y}$'s are the only terms that determine the slope of the employment share curves and thus, structural change in the long run. ($\frac{x_i}{X}\frac{C}{Y}$ denotes the ratio of sectoral consumption to aggregate output,

[8] We omit here the discussion of the shape of the x_i / X-curves, since they are the same as in the model of Ngai and Pissarides (2007).

since equation (28) implies that $\frac{x_i}{X}\frac{C}{Y} = \frac{p_i C_i}{Y}$.) A decrease in C/Y (see Effect 4) decreases the slopes of sectoral employment-share-curves (see equations (29)-(31)) which means that less labor is reallocated across sectors over time. That is, offshoring causes a slowdown of structural change (or in other words: structural change smoothing) in the long run, provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$. (A discussion of the shape of the x_i / X -curves can be found in Ngai and Pissarides (2007). The results of their model with respect to x_i / X 's are the same as in our model.)

Now, let us summarize these results as follows:

Lemma 5: *Offshoring leads to an increase in the exports-to-output ratio and to a decrease in the domestic-intermediates-production-to-output ratio (by the same amount). These effects have no impacts on structural change in the long run. Provided that* $\frac{\dot{p}_I}{p_I} - g_T > 0$ *(i.e. provided that offshoring is productivity enhancing) offshoring leads to an increase in the investment-to-output ratio. This effect has no direct impact on structural change in the long run; however, it decreases the consumption-to-output ratio in the long run. This means that consumption becomes a (quantitatively) less important part of aggregate output. Hence, the changes in consumption demand patterns* x_i / X *(that cause structural change) become less relevant for the reallocation of factors across sectors in the long run. Therefore, a structural change slowdown happens.*

All explanations regarding the development of sectoral employment shares n_i are also true for the sectoral capital shares k_i, intermediate input shares z_i (see equation (27)) and sectoral output shares $\frac{p_i Y_i}{Y}$ (see equations (29)-(31)).

In this section, we derived all the results for the case that, $\frac{\dot{p}_I}{p_I} - g_T > 0$. The results can be derived in the analogous way for the case that offshoring slows productivity growth down, i.e. $\frac{\dot{p}_I}{p_I} - g_T < 0$. Effects 1 and 2 remain unchanged. However, the Effects 3 and 4 are exactly reciprocal. That is, the investment-to-output ratio decreases and the consumption-to-output ratio increases due to lower productivity growth. Therefore, the consumption demand patterns become relatively more important for the reallocation of labor across sectors. Therefore, structural change patterns intensify in the long run.

5. Discussion and Implications

Our distinction between "level effects" and "growth effects" of offshoring on structural change in the previous section implied that only the "growth effects" have an impact on structural change in the long run. Therefore, the "level effects" can be regarded as transitory effects of offshoring with respect to structural change.

A further interpretation of the distinction between "level effects" and "growth effects" might be that the effects of offshoring will impact the economy in two phases: In this case the "level effects" might be regarded as phase-1-effects and "growth effects" might be regarded as phase-2-effects. That is, when offshoring starts (e.g. due to technological progress or due to opening of international borders) the economy must go first through phase 1. The reallocations during this phase are described by Effects 1-4 in the previous section: employment in domestic intermediate-inputs-industries decreases, employment in exports-industries increases, employment in capital-producing industries increases and employment in consumption-goods-industries decreases (provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$). Note that all these effects imply that labor is reallocated from all sectors to the capital-producing sector in phase 1 (provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$). That is, in phase 1 there is a kind of "manufacturing sector renaissance" (provided that we interpret the capital-producing sector as the manufacturing sector; see also p.10 and footnote 5). After this phase is accomplished, phase 2 starts where structural change is smoothed by offshoring (provided that $\frac{\dot{p}_I}{p_I} - g_T > 0$) as explained in the previous section.

Thus, overall, this interpretation implies that due to offshoring a turbulent phase 1 must be accomplished (where strong labor reallocations happen) before the structural-change-smoothing-phase begins. This result supports Blinder (2005, 2007a, 2007b) who emphasizes the possible negative (transitory) effects of offshoring. He argues that the reallocations during the transitory phase can cause high unemployment, since they require that the labor force changes its skill sets. This is especially true if the labor force has to be reallocated across sectors rather than within sectors, since different skill sets are required across sectors (for example, in the services sector soft skills are much more important than in the manufacturing sector). Our discussion of phase 1 implies that most of the labor force will have to be reallocated *across sectors* during this phase, which implies that indeed high unemployment can arise. Furthermore, our discussion of phase 1 implies as well that unemployment might be even higher than expected up to now: Most studies focus only on unemployment in the intermediates-industries, whereas our model implies that unemployment may arise also in the consumption-goods-industries (Effect 4) as well.

Note however, that phase 1 might be less turbulent if $\frac{\dot{p}_I}{p_I} - g_T < 0$ (i.e. if offshoring is not productivity enhancing): As explained in the previous section, the Effects 1 and 2 imply that labor is reallocated to the manufacturing sector. However, effects 3 and 4 imply that labor is reallocated from the manufacturing sector to the other sectors, provided that $\frac{\dot{p}_I}{p_I} - g_T < 0$. That is, the effects offset each other in part if $\frac{\dot{p}_I}{p_I} - g_T < 0$, thus, less labor must be reallocated across sectors in this case, which implies that less unemployment may arise.

A further interesting result from the previous section is that a sort of "partial offshoring" occurs. That is, only a part of the intermediates-production is offshored: the labor employed in the domestic intermediates production ($\varphi\beta$) does not decrease in the long run, but is constant (see discussion of Effect 2), i.e. the intermediates-production is not completely taken over by the foreign labor force. This is consistent with the experience from manufacturing sector offshoring: developed economies are still producing manufacturing goods.[9] To our knowledge, the only paper that models partial offshoring is the one by Choi (2007), where partial offshoring occurs due to uncertainty. Our results imply that partial offshoring occurs even when there is no uncertainty, provided that domestic intermediate inputs are essential for final-goods-production (in part) (see also the explanations on pages 8 and 9).

6. Application: Services Offshoring

Whereas offshoring of manufacturing activities is a well known fact, recently there has been increased interest in services offshoring (see e.g. Amiti and Wei (2005, 2006), Garner (2004), Blinder (2005, 2007b)). Services offshoring has become feasible (and will become even more

[9] See, e.g. Blinder (2007b).

feasible in the future) by progress in information and communication technology. Thus, a new source of international "trade" has arisen, that will gain on importance in the future.

However, not all services are offshorable. Whether a service job can be offshored depends on whether its output can be delivered (electronically) from afar without degradation in quality. Therefore, Blinder (2007a) suggests dividing the service jobs into **personally delivered (or personal) services**, i.e. services that cannot be delivered electronically from far away without degradation in quality (e.g. child care and surgery), and **impersonally delivered (or impersonal) services** that can be delivered electronically from far away without degradation in quality (e.g typesetting and programming). Impersonal services are offshorable (or tradable), but personal services are not. Hence, the term "services offshoring" in fact refers to impersonal services offshoring.

A very important feature of the division of services into personal services and impersonal services is the productivity-growth-difference across these two types of services: Productivity growth in the impersonal services sector is considerably higher than the productivity growth in the personal services sector (and in the manufacturing sector), since the productivity growth in the impersonal services sector is closely related to the fast progress in information and communication technologies.[10] Thus, while it is argued that offshoring of manufacturing activities included mainly low-productivity-growth-activities (see e.g. the discussion in Mankiw and Swagel (2006)), services offshoring may include high-productivity-growth-activities; see e.g. Blinder (2005, 2007a, 2007b) and Irwin (2005).

Thus, our Lemma 4 (and Definition 1) implies that the requirements for services offshoring to have positive growth effects might be harder to fulfill in comparison to manufacturing offshoring, since services offshoring will require steadily improving terms of trade in order to have positive GDP-growth-effects. (This fact is especially interesting if we keep in mind that theoretical literature implies that offshoring might have a negative effect on terms of trade in

[10] See also Blinder (2007b). Empirical evidence on low productivity growth of sectors that could be classified as personal services can be found e.g. in Baumol, Blackman and Wolff (1985).

industrialized economies (see e.g. Samuelson (2004) and Rodriguez-Clare (2004)). Manufacturing offshoring that has been occurring since the 1970s could have been associated with positive growth effects even if the terms of trade were worsening steadily. Thus, when comparing services offshoring with manufacturing offshoring, it seems to be less likely that services offshoring will have positive effects on GDP-growth.

7. Conclusion

Offshoring is a rapidly growing form of international trade. The accurate reaction to this trend is discussed controversially in the political debate (laissez faire vs. "protectionism"). Hence, from the scientific point of view it is necessary to understand the exact effects of offshoring in order evaluate this new trend and to provide a theoretical basis for political discussion. In our paper, we focused on the implications of offshoring for GDP-growth and structural change (in a framework where TFP-growth differs across sectors). This is a rarely researched topic, although it seems to be one of the most important ones, since the future growth rate and structural change patterns are relevant for nearly every type of economic policy.

We have shown that offshoring influences GDP-growth along different channels: offshoring acts like a kind of technological progress in intermediates production, since it integrates foreign cost-advantages into domestic production; furthermore, additional growth is generated by the capital-deepening-effect mentioned by Milberg et al. (2006) (see section 3). We have shown as well that due to "Baumol's cost disease" the terms-of-trade-development can have different implications for the aggregate growth rate depending on whether high-productivity-growth-activities or low-productivity-growth-activities are offshored (Lemma 4). In Lemma 3 we have proven that offshoring can cause even a growth-slowdown, provided that the domestic economy becomes dependant on foreign intermediates (e.g. petroleum products), since the substitution of foreign products by domestic products is associated with costs in this case.

In section 4 we elaborated the implications of offshoring for structural change. We have shown there that offshoring can accelerate or slow down the structural-change-patterns (depending on the development of terms of trade) via different channels: offshoring leads to changes in exports, domestic intermediates-production and investment. However, we have shown as well that, in the long run, offshoring influences structural change only via the investment-channel (since the effects that arise via the other channels offset each other). Furthermore, our results put the results of previous literature into new perspectives: We have shown in sections 3 and 4 that the growth-slowdown mentioned by Blinder (2005, 2007a) and the structural change acceleration mentioned by Fixler and Siegel (1999) occur only if the terms of trade develop unfavorably (i.e. if offshoring is not productivity-enhancing from the macro-economic perspective).

In section 5 we have discussed some further implications of our model. We have shown there that the effects of offshoring are distributed across two consecutive phases: When offshoring starts, strong structural changes (that can cause a manufacturing sector renaissance) will happen in order to adapt the production-structures to the effects of offshoring (changes in exports, investment and domestic intermediates demand). Thus our results support the view of Blinder (2005, 2007b) that offshoring can be associated with high unemployment due to sectoral reallocations during the transition period. However, we have shown as well that structural change is smoother (and thus less unemployment may arise) during this period if terms of trade develop unfavorably, since the different effects of offshoring on structural change offset each other in part in this case. When this phase is finished, a phase of potentially higher aggregate growth and structural-change-smoothing starts in our model (provided that the terms of trade develop favorably in the long run). Furthermore, we have shown in this section that “partial offshoring” occurs when domestic intermediates are in part essential for domestic production.

In section 6 we discussed the implications of our model results for services offshoring (which is a “new” type of offshoring). We have shown there that due to “Baumol’s cost disease” services offshoring may be less likely to have positive growth effects in the industrialized economies in comparison to manufacturing offshoring.

Overall, our results imply that offshoring cannot cause a reversal of structural change patterns in the long run, since we have shown that it causes only a smoothing or acceleration of the structural change patterns. However, such reversals could happen at the more disaggregated level. Thus, further research could focus on the disaggregation of the non-tradables sector P and of the tradables sector I in order to analyze whether foreign demand can cause structural change reversals across these sub-sectors in the long run. Furthermore, the model could be modified such that it explicitly incorporates unemployment, e.g. by integrating inter-sectoral barriers (e.g. due to skill-mismatch between sectors) with respect to labor. This framework could be used to analyze the effects of such barriers on the duration of the transition period and on the growth rate of aggregates. These topics are left for further research.

APPENDIX A

We know from equation (11) that h_I is produced by sector I. Thus, the total factor productivity (TFP) of h_I-production is given by the TFP of sector I. It follows from equation (4) that the TFP of sector I is given by A_I. Thus, we can formulate the following Lemma:

Lemma A1: *The TFP of the domestic intermediates-production (h_I) is given by A_I.*

Equations (7), (8) and (18) imply

(A.1) $$h_F = \frac{e_M}{T}$$

We know from equation (10) that e_M is produced by sector M. Thus, the TFP of e_M-production is given by the TFP of sector M. Thus, we can formulate the following Lemma due to equation (4):

Lemma A2: *The TFP of exports-production (e_M) is given by A_M.*

It follows from equation (A.1) and Lemma A2:

Lemma A3: *The implicit TFP of intermediates-imports (h_F) is given by $\frac{A_M}{T}$.*

Implicit TFP means here the TFP which is implied by the terms of trade and by the TFP of the export sector.

Equation (6) and Lemmas A1 and A3 imply that the implicit TFP of intermediates-production (Z) is given by $A_I^{\varphi}\left(\frac{A_M}{T}\right)^{1-\varphi}$. The growth-rate of this term (i.e. the implicit TFP-growth-rate of Z-production) is given by $\varphi g_I + (1-\varphi)(g_M - g_T)$. This term is equal to g_η, because of equations (25) and (35). **Q.E.D.**

APPENDIX B

Lemma 1 and equation (21) imply that the following relation is true along the ABGP:

(B.1) $$g^* = \alpha \frac{Y}{K} - \delta - \rho$$

This equation can be rearranged as follows:

(B.2) $$(\delta + g^*)\frac{K}{Y} = \frac{(\delta + g^*)\alpha}{g^* + \delta + \rho}$$

The first derivative of $\frac{(\delta + g^*)\alpha}{g^* + \delta + \rho}$ with respect to g^* is given by

(B.3) $$\frac{\partial\left(\frac{(\delta + g^*)\alpha}{g^* + \delta + \rho}\right)}{\partial g^*} = \frac{\alpha\rho}{g^* + \delta + \rho} > 0$$

Equations (B.2) and (B.3) and Lemma 3 imply that offshoring increases $(\delta + g^*)\frac{K}{Y}$ provided

that $\frac{\dot{p}_I}{p_I} - g_T > 0$. **Q.E.D.**

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