The effect of net immigration on economic growth in an ageing economy: transitory and permanent shocks

Working Paper Series

#2011-055

The effect of net immigration on economic growth in an ageing economy: transitory and permanent shocks

By Joan Muysken & Thomas Ziesemer

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

The effect of net immigration on economic growth in an ageing economy: transitory and permanent shocks[1]

Joan Muysken[a,c]
Thomas Ziesemer[a,b]

Maastricht University
The Netherlands

Abstract:

This paper argues that immigration can help to alleviate the burden ageing presents for the welfare states of most Western Economies. We develop a macroeconomic framework which deals with the impact of both ageing and immigration on economic growth. This is combined with a detailed model of the labour market, to include the interaction with low-skilled unemployment. The empirical relevance of some crucial model assumptions is shown to hold for the Netherlands, 1973 – 2009, using a vector-error-correction model. The conclusions from the analysis of transitory and permanent shocks are that immigration will help to alleviate the ageing problem in the long run, as long as the immigrants will be able to participate in the labour force at least as much as the native population. Moreover, the better educated the immigrants are or become, the higher their contribution to growth will be.

Key words: ageing; immigration; unemployment; skills.
JEL-codes: E24 F22 O15 O52

[a] Department of Economics, Maastricht University.
[b] UNU/MERIT and Department of Economics, Maastricht University.
[c] Corresponding author: J. Muysken, Department of Economics, SBE, Maastricht University, *address*: P.O. Box 616, 6200 MD Maastricht, The Netherlands, *tel.:* ++31(0)43-3883821, *fax:* ++31(0)43-3884150, *email:* j.muysken@maastrichtuniversity.nl.

[1] We thank Frank Cörvers for his contribution to the initial research on this problem and his help with the data in the current paper. We are grateful for useful comments from J.C. Dumont, R. Euwals, J. Hartog, G. Pfann, H. van Dalen and participants of the workshop 'Immigration and Growth', Amsterdam, 23-24 June 2011.

1. Introduction

Various studies have argued that immigration can contribute to solve a lack of labour supply that results from an ageing population – EU (2005), Freeman (2006). This notion also underlies the recent EU immigration policy, which includes the introduction of the 'blue card' to attract highly skilled workers mid-2011 (for a critical discussion see Parkes and Angenendt, 2010). Apart from this group of highly skilled migrants, also the admission and procedures for seasonal workers, paid trainees and intra-corporate transferees is becoming more and more regulated (see Koehler cs. 2010 for an overview of recent measures).

In this paper we investigate, using both a theoretical model and empirical analysis, under which conditions immigration does help to compensate a lack of labour supply that results from an ageing population. It is obvious that immigration alone cannot account for keeping our GDP at a high level, and we also need other measures like a rising rate of labour force participation, particularly in the older age classes (Münz, 2009). Therefore we include the ratio of the working age population to the total population in both our theoretical and empirical analysis. With respect to the empirical analysis we simply take the case of the Netherlands to illustrate our theoretical reasoning of how immigration can alleviate the ageing problem. In that context it is interesting to note that in the Netherlands there are many concerns among citizens, politicians and the CPB Netherlands Bureau of Economic Policy Analysis – an official independent research institute informing the Dutch government – on more liberal immigration policies (see e.g. Muysken et al. 2008).

Although the blue card seems to be a good instrument to attract more highly-educated individuals, we show that it may be beneficial to attract also immigrants who are not graduated from universities, as long as the skill distribution of the immigrants is on average not less favourable than that of the other labour market entrants. It is, however, very important that immigrants are in paid employment. We show that the benefits from immigration could proliferate further if policy makers focus successfully on an increase of the ratio of the working to the inactive population in general, which requires a better integration policy than in the past. The aim of our theoretical and empirical analysis is to illustrate the relevance of this ratio, in particular in relation to net-immigration.

Most of the literature on the impact of immigration on ageing focuses on the impact of immigration on the labour market and the welfare state with an emphasis on the short run – see Nannestad (2007) for an overview. A drawback of this focus then is that the impact of ageing and immigration on capital formation and economic growth usually are ignored. Razin and Sadka (1999, 2000) were the first who analysed the impact of immigration on ageing in a general equilibrium long-run context, taking this impact into account. They use a closed economy model, however. Moreover, in the tradition of long-run-focused general equilibrium analysis they model the labour market in a highly stylised way, assuming full employment. But for the typical European welfare state the interaction between immigration, unemployment and ageing problems cannot be ignored. We therefore start our analysis by developing a model of the labour market which enables us to analyse the interaction between immigration, unemployment and ageing problems. We also include internationally mobile capital as a production factor, to facilitate the link with economic growth.

Capital is modeled to be substitutable with high-skilled labour in a nested CES-production structure, where the other component is low-skilled labour. This also allows for more flexibility in the substitution between high and low skilled labour compared to the Cobb-Douglas production function which is usually assumed in this type of analysis (Kemnitz, 2003; Krieger, 2004; Boeri and Brücker, 2005; Brücker and Jahn, 2011).[2] Moreover, instead of the usual simple monopoly union model, we assume right-to-manage wage bargaining.

We include the long-run properties of the labour market model in our concise long-run macroeconomic model as a background for our analysis of the impact of immigration as a remedy to ageing and capital formation in Western economies. The properties of that model are in line with the model of Razin and Sadka – although we have extended the model to an open economy. Moreover, our model is flexible enough to allow for the inclusion of unemployment. Finally, an attractive feature of our macroeconomic model is

[2] Brücker and Jahn (2011) do allow for more flexibility in the substitution between high and low skilled labour, but capital is still included in a Cobb-Douglas framework.

that it pays explicit attention to the importance of social equilibrium and the role of the welfare state.

Since we use capital as a production factor, we can also use the insights of our macroeconomic model to discuss the interaction between economic growth, the labour market and the welfare state. Several interesting insights result from our analysis, which lead beyond the insights of using a Razin and Sadka type general equilibrium model or a labour market model separately. For instance we analyse simultaneously the impact of immigration on economic growth, while taking into account the interaction with both unemployment and ageing.

The set up of our paper is as follows. We present some stylised facts for the Netherlands in section 2, which also introduces the data we use in our empirical analysis. We then develop a model of the labour market in section 3 and incorporate the long-run features of that model in a macroeconomic theoretical model in section 4. Using the macroeconomic model we analyse the impact of immigration on welfare state and ageing problems. We argue that an important element is the extent to which immigration has a positive effect on the activity rate. For that reason we investigate empirically in section 5 to which extent such an effect could be found for the Netherlands, together with other predicted effects from our analysis using a vector-error-correction model. We find that the implications of our theoretical model can be corroborated for the Netherlands. Since we find a positive effect of immigration on the activity rate only for the first ten years after immigration, we conclude that for the Netherlands immigration can be used to alleviate the ageing problem if the integration and participation of immigrants in the labour market is improved. We elaborate and generalise this notion in our concluding remarks in section 6.

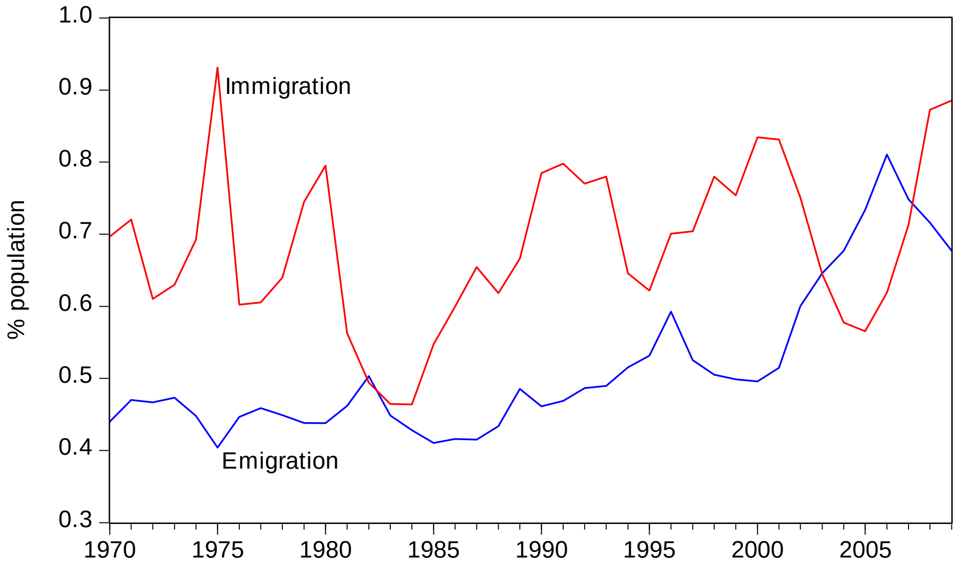
2. Stylised facts for the Netherlands, 1970 – 2009[3]

Population growth has been very low in the Netherlands, falling from 1.4% in 1960 to 0.4% in 1980 and fluctuating around that level thereafter. As a consequence of ageing, the share of population 65+ increased from less than 9 % of total population in 1960 to

[3] A more elaborate discussion is presented in Muysken and Ziesemer (2011b). The data sources are presented in Appendix I.

over 15 % in 2009, and it is predicted to increase till 25% in 2050. This has enormous implications for the sustainability of the welfare state. The two key challenges due to ageing are summarized by the OECD (2008, pp. 37 ff.) as follows: (1) returning public finances to a sustainable path, mainly in response to increasing care expenditures and pension benefits which have to be borne by a decreasing share of the population, and (2) compensating for labour market shortages due to a declining work force relative to the population by increasing labour market participation. With respect to the latter the OECD pays special attention to immigration, which has “traditionally been an important source of labour supply.”(p. 43).[4]

Figure 1 Immigration and emigration, 1970 -2009



From Figure 1 one sees that immigration fluctuates around 0.7% of population – this is higher than the average population growth of 0.4% mentioned above, which highlights the important role of immigration in population growth. From the figure one also sees that emigration is increasing somewhat, but net immigration is usually positive around 0.15% of population.

[4] However, the OECD recognises that the labour market performance of immigrants in the past decades has been poor and recommends various policy measures to improve labour market integration of immigrants (OECD, 2008, Ch. 5).

With respect to the characteristics of immigrants, the educational composition of the non-native population is summarised in Table 1. This shows that the immigrant population on average reflects quite well the native population in terms of education – not surprising the "non-western" part of the non-native population has a higher incidence of low education. Kim, Levine and Lotti (2010) show that the educational similarity of immigrants also holds for the EU15.[5]

Table 1 Educational composition of labour force, 2001 -2009 (average shares)

		Share in labour force	
		Native	Non-Native
Level of education	Low	0,25	0,30
	Medium	0,45	0,41
	High	0,30	0,28

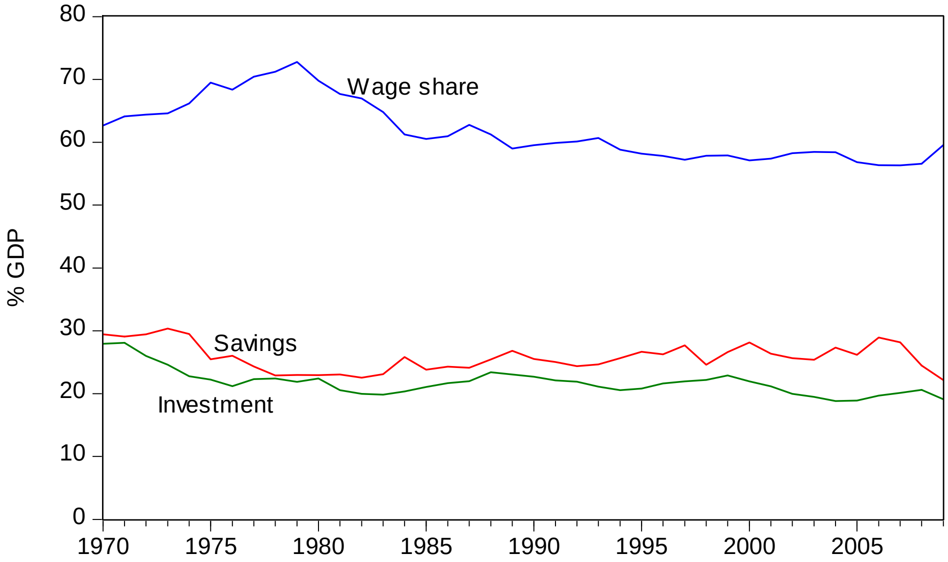
With respect to macroeconomic characteristics, three features deserve special attention since we will refer to these features in our macroeconomic model later:

First the Dutch economy is characterised by persistent excess of domestic savings over investment, consistent with a persistent surplus on the current account. The savings ratio relative to national income is relatively constant over time: It fluctuates around 25 per cent – see Figure 2. The investment ratio shows a slight tendency to decline, after a marked drop in the early 1970s.

A second feature is the stability of the wage share in GDP. After the turbulence following the oil-crises in the early 1970s, the share remained almost constant around 60 per cent, although a slight decrease over time can be discerned – see also Figure 2. The third feature which deserves attention is the observation that the strong increase in unemployment which occurred in the 1970s and early 1980s, and its secular decrease thereafter, is not reflected in the development of immigration, as can be seen from Figure 3.

[5] Table 1 includes the impact of net migration, since skill biased emigration would affect the skill structure of natives. Emigrants in the Netherlands are on average somewhat higher educated than natives (van Dalen and Henkens, 2011).

Figure 2 Savings, investment and wage costs (%GDP), 1970 -2009

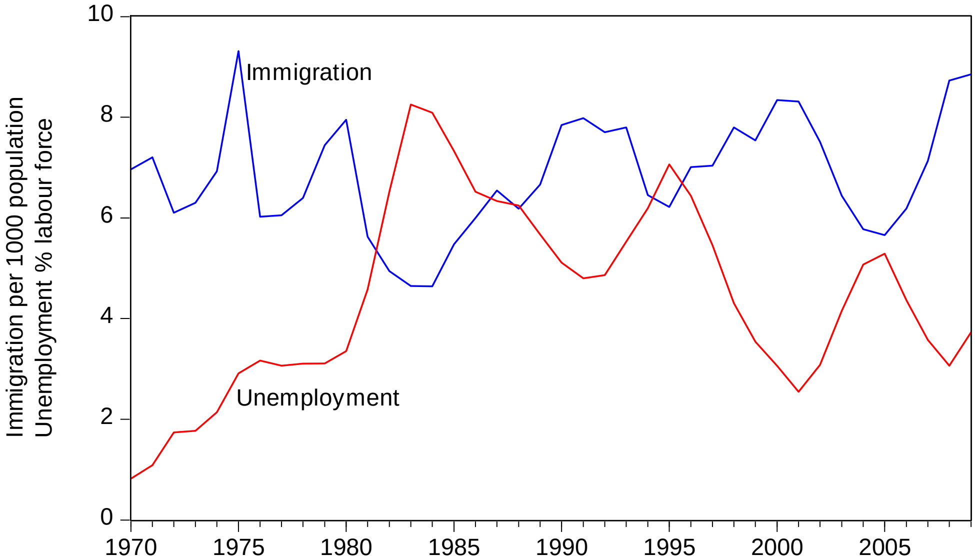


Both unemployment and immigration show clear cyclical fluctuations, as one might expect in opposite directions. However, the causality does not necessary run from immigration to unemployment, as is often presumed in the popular debate – see also Jean and Jiménez (2011) who make this point for OECD countries. Actually the reversed causality may be present in the data for the Netherlands. If that would be the case, we interpret this as a policy reaction function of immigration authorities.

The above observations corroborate the following stylised facts in our analysis:

(1) a consistently ageing population
(2) positive net immigration, with an education quite similar to that of the native population (but 5% more low skilled)
(3) a constant propensity to consume
(4) a constant ratio of labour income to GDP since the end of the 1980s.
(5) a persistent current account surplus, reflecting excess domestic savings
(6) no relationship between unemployment and immigration until 1980 and a countercyclical negative relation since 1980.These stylised facts will also appear in the model we develop below.

Figure 3 Unemployment and immigration, 1979 - 2009



3. A model of the labour market

As we mentioned in the introduction, models analysing economic growth usually ignore unemployment. However, when we look at the interaction between immigration and ageing in the context of the welfare state, unemployment should play a role. For that reason we first present a model of the labour market with wage bargaining, which allows for unemployment to occur. The long run properties of this model then will be included in a long run growth model which we develop in the next section.

To allow for capital accumulation as a source of economic growth, we distinguish physical capital as a separate production factor next to low and high skilled labour. We also allow for more flexibility in the substitution between high and low skilled labour by using a two-level CES-production function. Moreover, instead of a monopoly union model, we assume right-to-manage wage bargaining.

Our analysis proceeds as follows: We first present the production structure and firm behaviour. The process of wage formation and unemployment is analysed subsequently. Finally we derive some long run properties of our model, which we use in the macroeconomic model of the next section.

3.1. The production structure and firm behaviour

To allow for a reasonale flexibility, while still analytically manageable, we use a two-level CES-production function.[6] That is, output Y is produced according to a nested CES-production function allowing for the widely observed capital-skill complementarity:

$$Y = \left[(\lambda L)^{-\rho} + \left[(\partial H)^{-\phi} + (\iota K)^{-\phi}\right]^{\frac{\rho}{\phi}}\right]^{-\frac{1}{\rho}} \quad \sigma = \frac{1}{1+\rho} \geq 0 \tag{1}$$

H and L represent employment of high-skilled and low-skilled workers, respectively, and K is capital. The parameters λ, ∂ and ι are productivity parameters. Low-skilled labour has a constant elasticity of substitution σ with capital and high-skilled labour. The latter form a complex F with a constant elasticity of substitution, ς:

$$F(H,K) = \left[(\partial H)^{-\phi} + (\iota K)^{-\phi}\right]^{-\frac{1}{\phi}} \qquad \varsigma = \frac{1}{1+\phi} \geq 0 \tag{2}$$

When $\varsigma = 0$, capital and high-skilled labour are complements, as is sometimes assumed in the literature.[7]

This formulation of the production structure is much more general than Razin and Sadka (2000), who assume perfect substitutability between low and high-skilled labour, and Kemnitz (2003), who assumes the elasticity of subtitution to be unity ($\sigma = 1$) since he uses a Cobb-Douglas production function.[8] Many studies find capital-skill complementarity, which is associated with $\varsigma < 1$, and substitutability between high and low skilled labour, with $\sigma > 1$. See, for instance, Ben-Gad (2008) and Papageorgiou and Saam (2008). We will use these restrictions in our analysis.

Profit maximisation by the firm implies that marginal productivities should equal factor prices. Hence, when the low-skilled wage is w_L, the high-skilled wage is w_H and the interest rate is r, we find:

$$w_L = \frac{\partial Y}{\partial L} = \lambda^{1-\frac{1}{\sigma}} . \left[\frac{Y}{L}\right]^{\frac{1}{\sigma}} \tag{3a}$$

[6] Papageorgiou and Saam (2008: 120) note: "More recently, there is a revived interest in [this function] … Its flexibility, coming from the substitution parameters and an additional input, makes it an attractive choice for many applications in economic theory and empirics."

[7] Kemnitz (2003) uses this assumption to ignore capital in his analysis.

[8] The Cobb-Douglas production function is also used in Casarico and Devillanova (2003) and Krieger (2004) – and in more encompassing, applied models like Boeri and Brücker (2005) and Brücker and Jahn (2011).

$$w_H = \frac{\partial Y}{\partial H} = \left[\frac{Y}{F}\right]^{\frac{1}{\sigma}} .\partial^{1-\frac{1}{\varsigma}} . \left[\frac{F}{H}\right]^{\frac{1}{\varsigma}} \tag{3b}$$

$$r + \delta \leq \frac{\partial Y}{\partial K} = \left[\frac{Y}{F}\right]^{\frac{1}{\sigma}} . \iota^{1-\frac{1}{\varsigma}} . \left[\frac{F}{K}\right]^{\frac{1}{\varsigma}} \tag{3c}$$

The workforce consists of N_H and N_L high-skilled and low-skilled persons, respectively. Labour supply is exogenous – for an extension to endogenous labour supply see Krieger (2004).

3.2. Wage bargaining and social equilibrium in the presence of unemployment

The high-skilled labour market is competitive, which implies that the wage rate w_H is determined by full employment for all high-skilled persons.[9] The marginal productivity condition for capital holds with equality at some value denoted K* and with inequality in case of a capital constraint for K<K* (see below).

For low-skilled workers the wage is determined by union bargaining, where the unions take both the employment of high-skilled workers, which follows from labour supply, and the capital stock as given. We assume a right-to-manage model, where the bargaining power by unions equals ε – this encompasses Kemnitz' (2003) monopoly union model by setting $\varepsilon = 1$, and Razin and Sadka's (2000) full competition when $\varepsilon = 0$. Denoting the level of unemployment benefits by b and assuming a tax rate t_u, the expected income of a low-skilled worker is $(1 - u).t_u.w_L + u.b$, where u is the low-skilled unemployment rate, $u = (N_L - L)/N_L$. The firm negotiates with the unions about the wage, given its capital stock and employment of high skilled workers.

Social equilibrium requires that the employed pay taxes at a rate t_u to finance their unemployed colleagues. We assume a pay-as-you-go system where government sets the tax and benefit rates such that unemployment benefits are covered by tax revenues. Since we focus on low-skilled unemployment, we assume that the benefits are paid by taxes on

---

[9] This is also assumed in Kemnitz (2003). It is relatively easy to extend the model for separate wage bargaining of high-skilled workers, see Boeri and Brücker (2005) and Brücker and Jahn (2011) for an ad hoc application in a similar model of the labour market.

the low-skilled wage only.[10] While Kemnitz (2003) assumes that the tax rate t_u is determined a priori by government and benefits follow endogenously, we assume in line with the approach more commonly used in the literature – e.g. for instance Boeri and Brücker (2005) –that government sets a replacement rate β with respect to the *net* wage, and then the tax rate follows.

When setting the replacement rate at β, we find that the equilibrium rate of unemployment u^* is given by (see Muysken and Ziesemer, 2011b, reproduced in Appendix 2):

$$u^* = 1 - \frac{1}{1+\Psi} \quad with \quad \Psi = \frac{\beta.\varepsilon.\sigma - [1+\varepsilon.\nu.(\sigma-1)].[\lambda' + \varepsilon.(\sigma-1)]}{(1-\varepsilon).\lambda'.\beta} \tag{4}$$

We find the familiar result that equilibrium unemployment is higher the larger the replacement rate – see for instance Boeri and Brücker (2005).[11] Similarly, a higher union power ε also leads to a higher rate of unemployment, while an increase in low-skilled labour augmenting technological productivity, i.e. a higher value of λ, would lead to a lower rate of unemployment. Finally, an important observation is that from the analysis above it follows that the equilibrium unemployment rate of low-skilled workers, u^*, is not affected by the supply of low skilled workers.

Using equation (4), the aggregate rate of unemployment, u_{tot}, is given by:

$$u_{tot} = 1 - \frac{(1-u^*).N_L + N_H}{N_L + N_H} = \frac{N_L}{N_L + N_H} u^* \tag{5}$$

One sees that when the number of available low-skilled workers increases relative to the number of high-skilled ones, the aggregate rate of unemployment increases. However, when both numbers increase proportionally, the aggregate rate of unemployment is unaffected. The latter is consistent with stylised fact (6) from section 2, which shows that there is no secular relationship between unemployment and immigrants. Here one should also take into account stylised fact (2) that immigration is roughly speaking skill neutral.

---

[10] This assumption, which is in line with Kemnitz (2003), is motivated by analytical tractability. Including benefits paid by high skilled workers complicates the analysis considerably, without altering the qualitative results.

[11] $\lambda' = \lambda^{1-\frac{1}{\sigma}} > 0$; ν > 0 is a constant. A necessary and sufficient condition for positive unemployment is $\beta > [1-\varepsilon.\nu.(1-\sigma)].[\lambda' - \varepsilon.(1-\sigma)]/\varepsilon.\sigma$.

A final observation is that since $L = (1 - u^*).N_L$, we know from equation (3a) that the low skilled wage decreases when the supply of low-skilled workers increases. This is an important result since a popular perception is that most immigrant workers are unskilled and therefore immigration leads to a lower wage for unskilled workers. However, apart from the bias in this perception – see stylised fact (2) – , this result does only hold unambiguously in the short run, when the capital stock and skilled labour, H, are given. In the next section we analyse the interaction of changes in labour supply with the capital stock.

3.3. Long-run equilibrium in the labour market

To model economic growth we assume skill-neutral labour augmenting technological progress at a rate a, i.e. both λ and ∂ grow at that rate, while ι is a constant. Moreover, the labour force grows in a skill neutral way at a rate n, i.e. both N_L and N_H grow at that rate. These assumptions are not only motivated by analytical convenience, but also by our aim to show the impact of skill neutral immigration – which is consistent with stylized fact (2) – on economic growth.

The share of total labour income in GDP, α, is implicitly given by:

$$\frac{\alpha}{1-\alpha} = \frac{[\lambda.(1-u^*).N_L]^{1-\frac{1}{\sigma}} + [\partial.N_H]^{1-\frac{1}{\varsigma}}.F(K;N_H)^{\frac{1}{\varsigma}-\frac{1}{\sigma}}}{[\iota.K]^{1-\frac{1}{\varsigma}}.F(K;N_H)^{\frac{1}{\varsigma}-\frac{1}{\sigma}}} \tag{6}$$

which is a function of the capital stock. Since we assume $\sigma > 1$ and $\varsigma < 1$, we find that α increases with N_L and decreases with N_H, given K. However, α does not change when N_L, N_H and given K change with an equal proportion. We will use this relationship in our further analysis. It seems also consistent with stylised fact (4) from section 2, which shows that the ratio of labour income to GDP is constant over time.

The firm follows equation (3c) when determining its desired capital stock, given the world interest rate which is set at an exogenous level, r^*. Then the equilibrium capital stock, K^*, can be solved by substitution of equation (1) in (3c) at equilibrium levels of employment, which yields:

$$1-\alpha = \frac{(r^*+\delta)K}{\left[(\lambda(1-u^*)N_L)^{-\rho} + \left[(\partial N_H)^{-\phi} + (\iota K)^{-\phi}\right]^{\frac{\rho}{\phi}}\right]^{-\frac{1}{\rho}}} \tag{7}$$

Combining equations (6) and (7) then solves the equilibrium capital stock K^* as a linear homogenous function f of N_L and N_H :[12]

$$K^* = f(\lambda.N_L,\ \partial.N_H;\ r^*+ \delta\ ,u^*) \qquad f'_1, f'_2 > 0 \tag{8}$$

The equilibrium capital stock K^* increases through changes in net capital inflows when N_L or N_H increase, and it increases proportionally with N_L and N_H, when these grow at the same rate. A lower interest rate or a lower rate of low-skilled unemployment will lead to a higher equilibrium capital stock.

Because the constancy of the left-hand side of (3c) requires equal growth rates for Y, F, and K, it then follows from equations (8) and (3c) that output, Y, equilibrium capital, K, and the capital aggregate, F, will grow at a rate $a + n$, when there are no constraints on investment.

Finally, aggregate employment equals:

$$E = (1 - u^*).N_L + N_H \tag{9}$$

and the average real wage rate net of unemployment taxes is:

$$w = [(1 - t_u).w_L.(1 - u^*).N_L + w_H.N_H]/E \tag{10}$$

In the long run employment will grow at a rate n and the wage rate at a rate a - compare equations (3.a) and (3.b). We will use the properties of equations (7) – (10) in the long run model of the next section.

4. The long-run model of the economy

In the previous section, we presented a model of the labour market, where we assumed the capital stock to be determined at its equilibrium level for a given world market interest rate r^*. In this section we add household behavior to the model, to include

[12] Alternatively, equation (8) could be found be solved for by substituting equation (1) with equilibrium employment levels in the definition of the cost shares $1 - \alpha = (r^* + \delta).K/Y$. Using (6) and (7) does not use the marginal productivity conditions, whereas using (3c) and (1) with the employment levels found earlier does not use the income shares.

consumption and savings behavior. The overlapping generations structure of the model allows us to analyse the influence of the ageing process and of immigration on consumption and savings. Moreover, the possible presence of a home bias in asset formation also affects capital accumulation and economic growth – next to the impact of both ageing and immigration on productivity growth. The resulting model enables us to discuss the interaction between economic growth, the labour market and the welfare state. The welfare state plays a role in the analysis through the pay-as-you-go pension system, next to the provision of unemployment benefits.

We show that the model reproduces the ageing problem in a coherent way and provides a convenient tool to analyse the various ways in which immigration can enhance economic growth.

4.1. Household behaviour

To model consumption and savings behavior, next to the pension system, we distinguish between two generations. The younger generation ('young' for short) consists of N^y persons, of which E are working, saving and paying pension contributions. Aggregate employment equals $E = (1 - u^*).N_L + N_H$ and the average real wage rate is w. The remaining part of the younger generation is either unemployed or not in the labour force. The older generation ('old' for short) lives from pension benefits and dissavings; it consists of N^o persons.

The young contribute a share t_p of their income to pension benefits of the old in a pay-as-you-go system. The young both earn wages and have income from assets – we assume the young to own a share φ of total assets A in the economy. Disposable income of the young, Y^y, then equals:

$$Y^y = (1 - t_p).[w.E + r.\varphi.A] \tag{11}$$

The employed young consume a share c of their disposable income.[13] The unemployed consume their benefits $B = t_u.w_L.(1 - u^*).N_L$.

Disposable income of the old, Y^o, consists of their income from assets and the pension benefits financed by the young:

$$Y^o = r.(1 - \varphi).A + t_p.[w.E + r.\varphi.A] \quad (12)$$

The old do not only consume their disposable income, but also their asset stock at a rate ξ; hence their dissavings equal $\xi.(1 - \varphi).A$.

Domestic savings then equal savings of the young minus dissavings of the old:

$$S = (1 - c).Y^y - \xi.(1 - \varphi).A \quad (13)$$

Hence consumption is $C = c.Y^y + B + Y^o + \xi.(1 - \varphi).A$, and the accounting identities $X = Y^y + Y^o + B = w^gE + rA = C + S$ do hold for national income X, where $w^g = (w_L.(1 - u^*).N_L + w_H.N_H)/E$ is the gross wage rate per worker. The difference of national income with GDP, $Y = w^gE + rK$, is net foreign income. We discuss that in the next section.

4.2. Accumulation of capital and assets

As we discussed in section 3.3 above, both output and equilibrium capital will grow at a rate $a + n$, when there are no constraints on investment. However, when investment I is constrained for reasons we discuss below, the capital stock equals $K < K^*$ and a different rate of growth might result. One should realise that in that case firms also make profits, which they keep as retained earnings. These profits are given by:

$$\pi = r^*(K^* - K) \quad (14)$$

Taking into account that capital depreciates at a rate δ, gross investment I follows from:

[13] The constant propensity to consume of the young and full consumption of the old is consistent with intertemporal optimising behaviour; see for instance Razin and Sadka (2001) – see also stylised fact (3) from section 2.

$$I = K - (1 - \delta).K_{-1} \tag{15}$$

Since both savings S and retained earnings by firms π contribute to asset accumulation, we find:

$$A = A_{-1} + S + \pi \tag{16}$$

In a closed economy version of our model national income, $Y^y + Y^o$, equals GDP, Y, and assets are equal to the capital stock – there are no retained earnings. Asset accumulation then follows from $K = K_{-1} + S$ and consistency with investment requires: $S = I - \delta K_{-1}$, see equation (15). The equality between savings and net-investment is obtained by adjustment of the interest rate. As a consequence the interest rate is endogenous and no longer given by the world market. This is for instance the case in Razin and Sadka (2001).

The situation is different in an open economy context, where national income differs from GDP by net foreign income from abroad. Our stylised fact (5) shows that this has been positive for decennia in the Netherlands. In an open economy version of our model with perfect capital movements assets accumulate according to equation (16). In that case capital accumulates at a rate of growth $a + n$ as we discussed above; it has an impact on S via w but there is no feedback from assets A on capital K.

We prefer a more general approach which encompasses both extremes of a closed economy and an open economy with perfect capital movments. Due to the presence of a home bias and habit formation, we assume that a certain proportion μ of the assets in a country will be invested in the domestic capital stock with no impact of a small open economy like the Netherlands on the world market interest rate r^* – see also Holinski, Kool and Muysken (2009) and Mondria and Wu (2010). Moreover, due to home bias and habit formation in the rest of the world, the gap between the desired capital stock and domestically available assets can be filled through capital flows by only a fraction λ, a parameter for openness in regard to capital flows. This implies for the capital stock

$$K = (1 - \lambda).\mu A + \lambda.K^* \tag{17}$$

One sees that when both $\lambda = 0$ and $\mu = 1$, holds $A = K$ and we are in the closed economy situation and savings equal investment – the endogenous interest rate then also guarantees that (3c) holds with equality but probably at a different interest rate. When $\lambda = 1$ we find $K = K^*$ – then home bias plays no role and there are no constraints on investment. In that case the equilibrium capital stock K^* will always be obtained at the world market interest rate, compare equation (8). For values of openness between these extremes, lower home asset preference and lower openness reduce the capital stock if desired capital $K^* > \mu A$. This can be seen by subtraction of K* from both sides of (17).

In our more general approach we can derive from equations (11), (13), (14) and (16):

$$r^*K^* - r^*(1 - T.\ \alpha^*)K = [1 - T.\varphi.r^* + \xi.(1 - \varphi)].A - A_{-1} \tag{18}$$

with $\alpha^* = \alpha/(1 - \alpha)$, $T = (1 - c)(1 - t_p)$ and using $\alpha^* r^* K = wE$. Combining this with equation (17), in the constrained case, and the observation that K^* grows at a rate $a + n$, i.e.

$$K^* = (1 + a + n).\ K^*_{-1} \tag{19}$$

yields a dynamic system of three equations in K, K^* and A. The dynamics of the system (17) – (19) is analysed in Appendix 3.

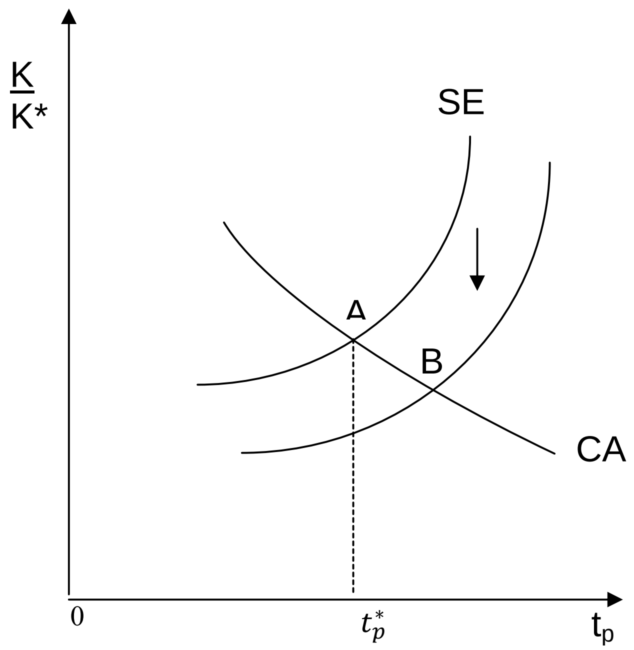
We concentrate on stable cases of imperfect capital movements, $\lambda < 1$, and some home investment $\mu > 0$, that lead to a positive steady-state value for the ratios A/K^* and K/K^*.[14] Moreover, we are in particular interested in the impact of the rate of contribution t_p on capital. In the Appendix we show that higher pension premiums t_p lead to lower values of the capital to efficient capital ratio, K/K^*, provided some home bias is present. Hence we find:

[14] Several other cases are discussed in Appendix 3.

$K/K^* = k(t_p) \qquad\qquad k' < 0$ (20)

Starting from an initial value t_p^*, a fall in t_p then will lead to higher capital growth in the transition process. The intuition is that a higher contribution rate leads to a lower rate of capital growth, since fewer funds are available for investment, because they are used for the consumption of the old as in equation (12). As a consequence a lower capital stock will result in the steady state and in the transition.

Figure 4 The CA and SE-curves



The downward sloping relation between the capital ratio k and the contribution rate t_p is presented in Figure 4. We name this relationship the capital-accumulation or CA-curve, since for each contribution rate t_p we get a different capital ratio, as long as capital accumulation is related to growth of domestic assets, $\lambda < 1$. The curve will shift upwards when the propensity to consume c decreases, since more income then will be saved at the same contribution rate. The same occurs when the old dissave less, that is when ξ decreases or φ increases, and when productivity growth and population growth, $a + n$, decrease. Finally, a higher share of labour income α and a higher interest rate r also lead to an upward shift of the CA-curve. When $\lambda = 1$, i.e. absence of home bias, the CA-curve is the horizontal line at unity.

4.3. Social equilibrium in the welfare state

Next to unemployment compensation, see the discussion in section 2.2, social equilibrium in the welfare state also requires that consumption per capita of the old is at least equal to a constant fraction η of consumption per capita of the young. This is a matter of social responsibility, since the old have contributed in their young days to the development of the economy as it is now for the young. Moreover, political reality requires that the old have sufficient benefits, since they represent a growing part of the electorate in an ageing economy. Social equilibrium then requires:

$$\eta.c.Y^y/N^y = [Y^o + \xi.(1 - \varphi).A]/N^o \tag{21}$$

where N^y and N^o represent the number of young and old, respectively. The term in brackets of equation (21) is consumption of the old.

Substituting equations (11) and (12) in equation (21) yields:

$$K = \left[\frac{1}{\eta.c.(1-t_p).\frac{N^o}{N^y} - t_p}.\frac{r+\xi}{r}.\frac{1-\varphi}{\propto^*} - \frac{\varphi}{\propto^*}\right].A = x_1.A \tag{22}$$

Combining this equation with equation (17) yields in the constrained case:[15]

$$K = \lambda\frac{x_1}{x_1-(1-\lambda).\mu}K^* \tag{23}$$

Equation (23) shows that the rate of growth of capital consistent with social equilibrium is that of K*, $a + n$, as long as the other parameters of the model remain constant. However, any change in the parameters constituting x_1 will lead to a change in the ratio K/K^* and hence will have at least intermediate growth effects. For instance, an increase

[15] Provided that holds: $t_p > \left[\eta.c.\frac{N^o}{N^y} - \frac{1-\varphi}{\varphi+(1-\lambda).\mu\propto^*}.\frac{r+\xi}{r}\right] / \left(1 + \eta.c.\frac{N^o}{N^y}\right) > 0$. This also ensures $x_1 > 0$.

in the rate of contribution t_p will lead to an increase in the ratio K/K^* and hence to at least a temporary increase in the growth rate of K. This is intuitively plausible since a higher rate of growth implies higher consumption growth of the young relative to the old when the contribution rate is low. This may compensate the effect that a higher premium increases consumption of the old relative to that of the young.

For that reason the social equilibrium equation (23) is presented as the increasing SE-curve in Figure 4. The curve will shift downwards when the share of the old, η, is getting higher, or the propensity to consume c has increased. By implication, ageing moves the economy from equilibrium point A to B with a higher pension premium and a lower capital stock and therefore a lower transitional growth of the economy. Finally the curve shifts upwards in case of a lower share of labour income in GDP α and a lower return on investment r.

The SE-curve intersects with the CA-curve at the contribution rate t_p^*.[16] The steady state capital stock is given by $K = k(t_p^*).K^*$ and grows at a rate $a + n$.

4.4. Economic growth in an ageing economy and the impact of immigration

The model we have developed above, and which is summarised in Figure 4, can be used to illustrate the ageing problem outlined in section 2. In our model ageing is respresented by an increase in the ratio of old to young, N^o/N^y. In terms of Figure 4 ageing then induces a downward shift of the SE-curve. Starting from equilibrium in point A on the intersection of the CA-curve and the SE-curve, at a rate of growth $a + n$, and a rate of contributions t_p^*, the downward shift of the SE-curve leads to a higher rate of contributions and a lower rate of growth. The intuition is that a larger part of the income of the economy cannot be used for capital formation but is necessary to provide consumption for the old and therefore reduces savings. The economy will shift along the CA-curve to point B and beyond, if ageing continues. If all other things remain equal, ageing will lead to a continuously lower growth rate and require ever higher pension contributions to maintain social equilibrium. This summarises the ageing problem in a concise way.

[16] The contribution rate t_p^* is defined by solving t_p from $\frac{x_1}{x_1-(1-\lambda).\mu} = k(t_p)$.

Although we focus in our model on the restrictions to capital growth, there are also other mechanisms through which ageing of the economy will lead to lower growth, in particular lower growth per capita. To elaborate this, we decompose GDP per capita as follows:

$$\frac{Y}{P} = \frac{Y}{K} \cdot \frac{K}{E} \cdot \frac{E}{N} \cdot \frac{N}{P} \tag{24}$$

where E represents employment, N the labour force and P population. Since in our model both the interest rate and the share of labour income are fixed, the capital output ratio is fixed too and output growth equals the growth of capital. This explains why the first term of the right-hand side of equation (24) is constant, and output growth follows from the model above, as is summarised in Figure 4.

The growth rate of the second term of the right-hand side converges in our model to productivity growth a. There is ample evidence of a negative impact of ageing on productivity: Although most macroeconomic studies are quite agnostic about the mechanisms, they find consistently an inverse U-shaped relation between the share of workers in different age groups and productivity – see Feyrer (2007), Gómez and Hernández de Cos (2008), Werding (2008) and Lindh and Malmberg (2009). Most studies point at microeconomic evidence which shows that experience increases with age in initial stages, but has decreasing returns later on.[17] As a consequence of the negative impact of ageing on productivity, the CA-curve will shift upwards in Figure 4 (see also Appendix 2). Hence this constitutes an additional channel through which the ageing problem intensifies as reflected by a higher value of t_p, but it also leads to higher values of K/K^* and K/E.

The secular decrease in unemployment in the Netherlands, see Figure 3 above, led to an increase in the ratio of employment to labour force (although this should be corrected for hours worked per person), compare the third term of the right-hand side in equation (24). However, as we also mentioned in section 2, the share of old persons in the population increased strongly, inducing a decrease in the last term of the right-hand side.

[17] For microeconomic evidence see Vandenberghe and Waltenberg (2010) and the literature reviewed therein. See also OECD (2008, Box 1.7) for a nuanced view.

The expectation for the future is that this last effect will be dominant. From that perspective it is not surprising that economic policy is focusing on reducing the ratio old relative to young – or more precisely, to increase the ratio of the working to the inactive population. One way to enhance this process is to increase the retirement age – in the model some ‘old’ then become ‘young’ and the SE-curve shifts upwards in Figure 4, mitigating the impact of the ageing problem. A similar effect is obtained by encouraging immigration, which usually consists of young persons. This leads to both an upward shift in the SE-curve and increased economic growth through growth in labour supply.

Next to the demographic effect there is also another mechanism which is important in case of skill neutral migration. Kim, Levine and Lotti (2010) argue that skill neutral migration enhances growth for two reasons. First since migration takes usually place from low productivity to high productivity countries, economic growth is enhanced.[18] Second, immigrants usually start in jobs for which they are overqualified, this also enhances productivity growth. Some evidence for the latter is provided by Huber cs. (2010). Following the positive impact of immigration on productivity growth, the CA-curve will shift downwards in Figure 4. However, this indirect negative effect on the rate of growth will probably be overcompensated by the positive direct effect on the growth rate of effective capital. This provides an additional channel through which immigration enhances economic growth.

For all these reasons a higher rate of growth can be realised through immigration, without increasing the rate of pension contributions – provided that the immigrants are included in the workforce. Variants on this line of argumentation are also followed by the United Nations, the European Union and the OECD in their advice to allow for more immigration (UN, 2000; EU, 2005; OECD, 2008).

[18] This effect may be dampened if the movement goes from high productivity sectors in poor countries to low productivity sectors on rich countries, because if the migration is skill neutral in the host country it is kill biased in the country of origin. Moreover, if the countries of origin switch from innovating to non-innovation in reaction to the migration this will also reduce growth; e.g. the critical level of human capital in Romer-type models of technical may not be reached anymore (see Rivera-Batiz and Xie, 1993).

5. Empirical evidence on the impact of immigration on GDP/capita for the Netherlands, 1973 -2009

In the previous section we argued that immigration has a positive impact on economic growth through two channels. First the ratio of active over inactive persons, the activity rate N^y/N^o in our model, has a positive impact on the growth rate and therefore immigration has a positive effect too, if the percentage increase in active persons is larger than that of inactive persons. The second channel is that immigration enhances productivity growth. In this section we provide some empirical evidence for these statements using data for the Netherlands.

To analyse the first channel, the crucial question is, which impact immigration has on the ratio of hours worked per person in the population and which impact the latter has on GDP per capita. For that reason we use the ratio of the total hours worked, L, over the total population, P, to capture the activity rate. In the first channel capital accumulation also plays an important role – see Figure 4 above. For that reason we also include the investment to GDP ratio in our analysis. Finally, important features of our theoretical model are that the unemployment rate is not affected by skill neutral immigration, and wage growth remains consistent with productivity growth. We therefore also include wages and unemployment in our empirical analysis. Since productivity growth cannot be observed directly, we can only measure the impact of the second channel indirectly. Because we find that immigration indeed has a positive impact of economic growth, but the impact on investment is only marginal, if not negative, we conclude that the second channel plays an important role.

Our empirical analysis is on the Netherlands, during the period 1973 – 2009. The data for population, GDP per capita and gross fixed capital formation in constant 2000 Euros are taken from the World Development Indicators. Wage data are labour compensation per hour worked deflated by the GDP deflator from the KLEMS data base with adjustment of their base year from 1995 to 2000, and two observations added using growth rates from CPB. Employed persons in terms of 1000 full-time equivalents, hours worked per full-time equivalent and unemployment data come from the CPB using the international definition for the latter. Migration data are from the CBS. Precise sources are provided in Appendix 1, and a general description of the data used has been given in section 2.

The empirical analysis proceeds in two steps.[19] First, we want to show that total hours worked per person in the population, which is lower under ageing and probably higher under immigration, has a positive impact on the GDP per capita. We estimate a vector-error correction model in the natural logarithm of (i) GDP per capita, *log(y)*, (ii) the ratio of gross fixed capital formation as a share of GDP, *log(I/Y)*, (iii) the ratio of hours worked by thousand full-time equivalent workers per person in the population, *log(L/P)*, (iv) real wages, *log(w)*, (v) the unemployment rate, *u,* and *(vi)* net immigration per person in the population, *NMP* = (*im-em)/P*. Since we find that net immigration indeed has a positive impact on hours worked per person, we also use the estimated model to analyse the impact of both a temporary and a permanent shock in net immigration. Consistent with our model predictions, we find that immigration has a positive impact on GDP per capita for both types of shocks. The short-run effects can be somewhat volatile, however.

The vector-error correction model used in the first step of our analysis uses three lags and information on longer lags is ignored. Moreover, for policy recommendations the relevant policy variable is gross rather than net immigration. For those reasons we investigate in the second step of our analysis to what extent gross immigration has a positive impact on the *L/P* ratio when more lags are allowed for. Our findings indicate that the positive impact of immigration on hours per person vanishes after ten years. The challenge for immigration and integration policies therefore is to find a way to increase the activity rate permanently after immigration.

5.1 The vector-error correction model (VECM)

A vector-autoregressive model (VAR) in the six variables indicated above and a time trend is unstable if it has four lags. When only three lags are allowed, all lag length

[19] The indication for unit roots according to standard augmented Dickey-fuller tests are ambiguous. Muysken et al. (2008) found absence of unit roots using fewer observations. This result is typical of unit root test with lower power at lower numbers of observations. The probabilities for unit roots were low though, when regressors in addition to constant and trend, the package routine, were included (see Davidson and MacKinnon 2004, chap. 14.4). However, variables that are integrated of order zero and unity can both be included in error-correction models. Therefore we do not present results for unit roots.

criteria but one (Schwarz Information Criterion) indicate that three lags are optimal. The VAR with three lags is stable. The corresponding Johansen cointegration test with two lags indicates five cointegrating equations,[20] which are long-term economic relations, at the 5% significance level for MacKinnon-Haug-Michelis p-values according to both the trace test and the maximum-eigenvalue test. These long-term relations, with the left-hand side equal to zero in equilibrium, are as follows (with t-values in parentheses):

$$CE1 = \log(y)_{t-1} \underset{(-34.0)}{-\, 0.865}\log(L/P)_{t-1} \underset{(-33.6)}{-\, 0.0155}\text{trend} - 9.64 \tag{25}$$

$$CE2 = \log(I/Y)_{t-1} \underset{(5.35)}{+\, 0.42}\log(L/P)_{t-1} \underset{(3.92)}{+\, 0.0023}\text{trend} - 2.99 \tag{26}$$

$$CE3 = \log(L/P)_{t-1} \underset{(-52.6)}{-169.7}(NMP)_{t-1} \underset{(-6.54)}{-\, 0.0298}\text{trend} + 1.90 \tag{27}$$

$$CE4 = (NMP)_{t-1} \underset{(-23.05)}{-\, 0.0084}\log(w)_{t-1} \underset{(9.16)}{+\, 0.002}\text{trend} + 0.014 \tag{28}$$

$$CE5 = \log(w)_{t-1} \underset{(17.69)}{+\, 0.03}u_{t-1} \underset{(-8.12)}{-\, 0.007}\text{trend} - 2.79 \tag{29}$$

Equation (25) indicates that a percentage change in *L/P* translates into the GDP per capita with a factor of 0.865.[21] Note that on the basis of a linearly homogenous production function, *Y/P = F(K/P, L/P)* and a marginal product of capital equal to the sum of given – through perfect capital movements – interest and depreciation rates, a simplified version of equation (3c) above, one would expect a one-to-one relation between *L/P* and *Y/P*. Clearly our result of 0.86 is close to the one-to-one relation and suggests the greater realism of equation (3c) and slightly imperfect capital movements as in our theoretical model. The investment ratio decreases by a factor 0.42 according to equation (26) – we interpret that as a substitution effect between labour and capital. Net immigration

[20] Identification of the *r=5* cointegrating vectors requires at least *r-1=4* restrictions setting coefficients in the long-term relations to zero (see Patterson 2000, chap.14). As we have six variables in each long-term relation four zeros lead to bi-variate long-term relations.

[21] For the related literature on migration and growth based on closed economy models see Boubtane and Dumont (2010).

increases the hours-per-person ratio according to equation (27), which is consistent with the notion in our theoretical model that immigration increases the activity rate N^y/N^o – we elaborate the estimated impact of a shock in net immigration on the other variables below. Unemployment decreases the wage in equation (29), which is the well-known Phillips curve effect. And wages enhance net immigration in equation (28) – this is consistent with observations by Nannenstad (2007). Moreover, equations (28), (27) and (25) imply a two-way causality between growth and migration.[22]

All equations have highly significant time trends. At a constant *L/P* ratio there would be a growth rate of 1.55% in equation (25) as one finds it in the growth literature – see Jones (1995) and Mankiw, Romer and Weil (1992). This should also be approximately the long-run growth rate of wages in equation (29). However, the trend in equation (29) is considerably smaller due to the strong fall in unemployment during the time period under consideration (see Figure 3 above). The significant time trend in equation (28) also captures the trend in wages and that of emigration (see Figure 2 above). The small but significant time trend in equation (26) is probably a feature of the time under consideration with a slightly decreasing investment ratio, but will probably not be a long-run property. Finally, the time trend in equation (27) indicates that the increase in hours per person since 1985 is stronger than the fall from 1970 to 1985. As the investment share, I/Y, and working hours per person, L/P, and the unemployment rate are very unlikely to grow in the long run their time-trends should not be interpreted as steady-state results. Indeed, solving the long-term relation (25)-(29) for a constant unemployment rate u of 4%, we get very small growth rates for the *I/Y* and *L/P* ratios: -0.0032 and 0.002 respectively.

The complete VECM consists of the following six equations (t-values in parentheses, R^2 are adjusted), where we do not show the first and second lags of first differences of all variables here (these are shown in Appendix 4; their position is indicated by '…'):

[22] In contrast, on the basis of bi-variate correlations Ortega and Peri (2009) find no impact of bilateral migration on the L/P ratio for a panel of OECD countries, 1980-2005. Similarly, Morley (2006) uses an ARDL approach for two variables, immigration per capita and GDP per capita, and finds causality going from GDP to immigration but not the other way around for Australia, Canada and the USA, 1930-2002. Note, that two-variable approaches can have only one cointegrating equation for the analysis of two directions of causality. Our multi-variable approach has one cointegrating relation for each causality direction under consideration.

$$d(\log(y)) = \underset{(-2.13)}{-0.62CE1} \underset{(4.32)}{+0.66CE2} \underset{(2.65)}{+0.366CE3} \underset{(2.73)}{+59.2CE4} \underset{(5.8)}{+1.22CE5} + \ldots \underset{(1.36)}{+ 0.017} \quad R^2: 0.54 \tag{30}$$

$$d(\log(I/Y)) = \underset{(-2.06)}{-1.14CE1} + \underset{(3.23)}{0.69CE3} + \underset{(3.33)}{108.36CE4} \underset{(6.49)}{+1.84CE5} + \ldots \underset{(-2.84)}{-0.048} \quad R^2: 0.78 \tag{31}$$

$$d(\log(L/P)) = \underset{(2.94)}{0.256CE2} + \underset{(2.06)}{0.148CE3} + \underset{(1.96)}{23.06CE4} + \underset{(3.8)}{0.46CE5} + \ldots \underset{(-0.52)}{-0.0036} \quad R^2: 0.77 \tag{32}$$

$$d(u) = \underset{(-2.18)}{-21.65CE1} - \underset{(-3.65)}{11.93CE2} \underset{(-4.75)}{-16.36CE3} \underset{(-4.78)}{-2485CE4} - \underset{(-5.16)}{24.08CE5} + \ldots \underset{(-0.25)}{-0.07} \quad R^2: 0.86 \tag{33}$$

$$d(\log(w)) = \underset{(2.71)}{1.18CE1} - \underset{(-2.29)}{0.37CE2} + \underset{(2.61)}{0.38CE3} + \underset{(2.83)}{62.07CE4} - \underset{(-1.74)}{0.36CE5} + \ldots + \underset{(3.43)}{0.04} \quad R^2: 0.74 \tag{34}$$

$$d(NMP) = \underset{(2.7)}{0.07CE1} + \underset{(2.54)}{0.02CE3} + \underset{(1.97)}{2.26CE4} + \ldots \underset{(0.41)}{+0.0003} \quad R^2: 0.58 \tag{35}$$

Adjustment coefficients with t-values below unity have been restricted to zero before each re-estimation in order to keep the model simpler. For the imposed restrictions the LR test has a significance level of $p(\chi^2)=0.50$.

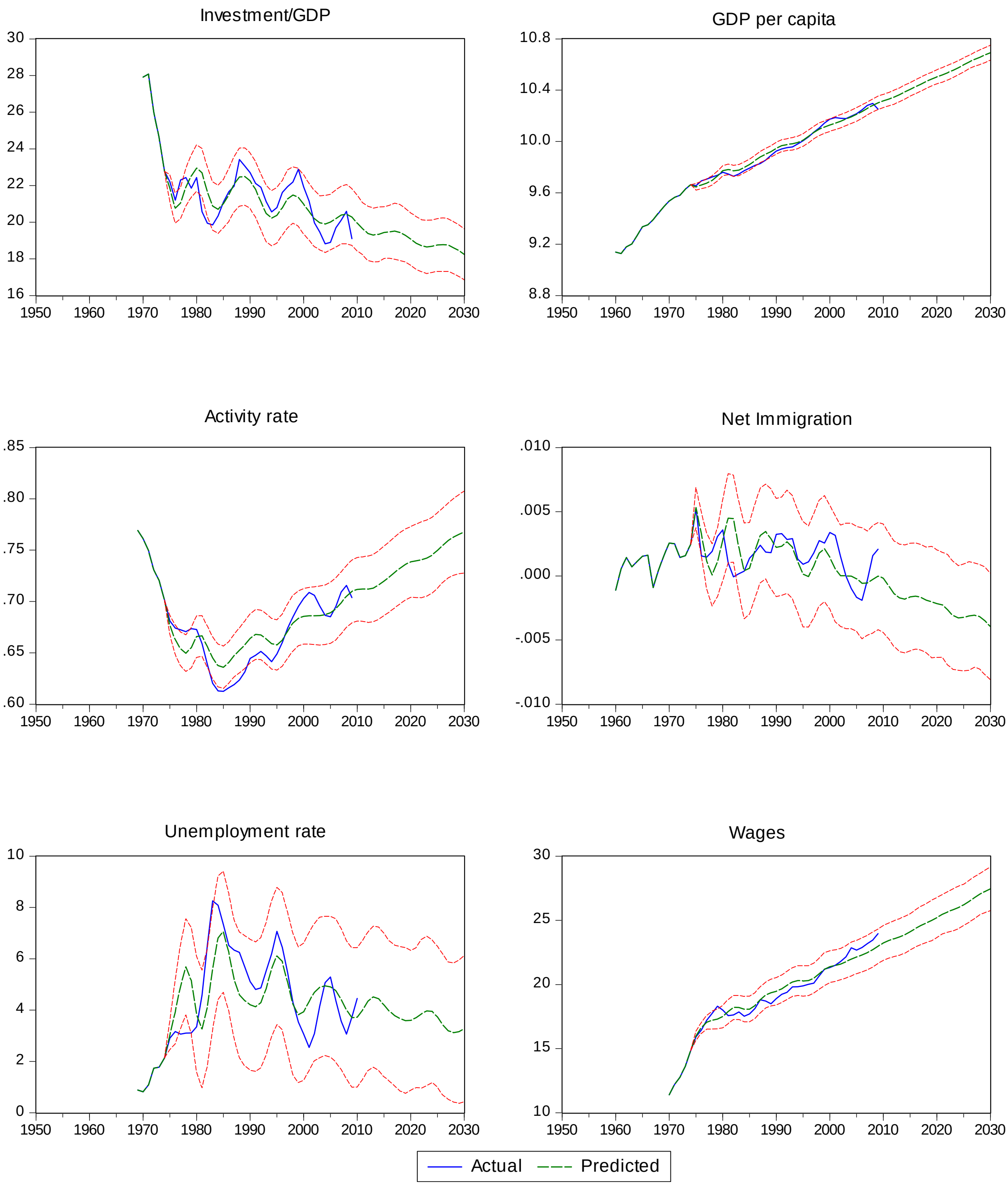
Equation (30) is a growth equation, where the standard population growth term has been replaced by the *log(L/P)* term and the arguments are spread over all error-correction terms. For example investment enters via the second error-correction term, CE2. Equation (31) is an investment equation, where the growth rate of the investment ratio depends on all error-correction terms besides the long-term relation for investment itself. Equations (32) – (35) show feedback effects of the cointegrating equations on changes of *L/P*, unemployment, wage rates and immigration. Only equations (31), (32) and (35) have in total four insignificant adjustment coefficients, which have been constrained to zero.

We demonstrate the working of the model in Figure 5, which shows the results of a dynamic stochastic simulation with thousand runs of a Monte Carlo approach (only using the observed values in the base year(s) as starting values for the variables).[23] The data for unemployment are outside the interval of two standard deviations only for the period of the second oil crisis in 1979; data for hours worked per person and net immigration are

[23] Data are in natural logarithms except for migration and unemployment.

outside the interval after the start of the wage-moderation policy in 1982 and for investment share in both of these periods. In brief, only during times of severe shocks do the data go out of the interval of two standard errors.

Figure 5 Dynamic Stochastic simulation of the VCEM model (with ± 2SE bounds)



In particular, our model nicely traces the u-shaped development of hours per person, *L/P*, with its minimum value in 1985, the inverted u-shape of the unemployment data and a similar but much milder inverted u-shape in the net immigration data. This is remarkable because the model is based on a linear VAR. Each economic variable though has in principle three types of coefficients, those in the long term relation, the adjustment coefficients, and the coefficients of the first-differenced lags. Together they are well capable of capturing non-linear developments in the data.

A second observation from the simulation results presented in Figure 5 is that the endogenously simulated development of all variables over the next twenty years shows time trends which are quite plausible. This shows that in the out of sample simulation the time trends in the long term relations do not cause serious problems, at least in the medium run.

A third observation is that the estimation results are very robust as we found in various earlier versions of this paper. In Muysken et al. (2008) we estimated the model in single equation form, using data till 2003/2005, and using slightly different sources; in Muysken and Ziesemer (2011a) we estimated the model in an error correction specification, without migration, using data till 2007; and in Muysken and Ziesemer (2011b) we estimated the model in an error correction specification, including gross immigration, using data till 2009. The conclusions and simulation results from all these estimations are remarkably similar to the analysis of this paper, where we also used data till 2009. Hence the results are quite robust with respect to the periods of observation and the data sources.

A final point which should be observed is that the estimation results using either gross or net immigration or joint or separate estimation of the equations for migration are also highly similar. In Muysken and Ziesemer (2011a, b) we found similar results for gross immigration rather than net immigration.[24] This can be seen as an indication that it

[24] When gross immigration and gross emigration both as a share of the population are considered separately, immigration has no unit root but emigration does, and they are not cointegrated – all with and without logs, with and without dividing by the population. The estimation in first differences with use of an ARMA(4,4) then is (t-values in parentheses)

$$D(\log(em/p)) = \underset{(1.16)}{0.012} \underset{(-3.91)}{-0.24} D(\log(im/p)) \qquad \text{Adj. } R^2 = 0.35$$

is in particular immigration which is the main driving force in the relation between migration and growth, at least in the Dutch and Western European context. That observation might also be one of the explanations why migration policy is mainly focussed on immigration rather than emigration.

5.2 Effects from net immigration shocks

Consistent with our theoretical model, we have found that net immigration indeed has a positive impact on hours worked per person. We then can use the empirical model results to simulate the effect of a shock in net immigration on the other variables in the model – a much debated answer to the ageing problem. We look at the effects of both a temporary shock and a permanent shock. In both cases we find a positive effect on GDP per capita in the long run, but the transition path shows some volatility, also depending on the nature of the shock.

Permanent effects and adjustment from a transitory net immigration shock

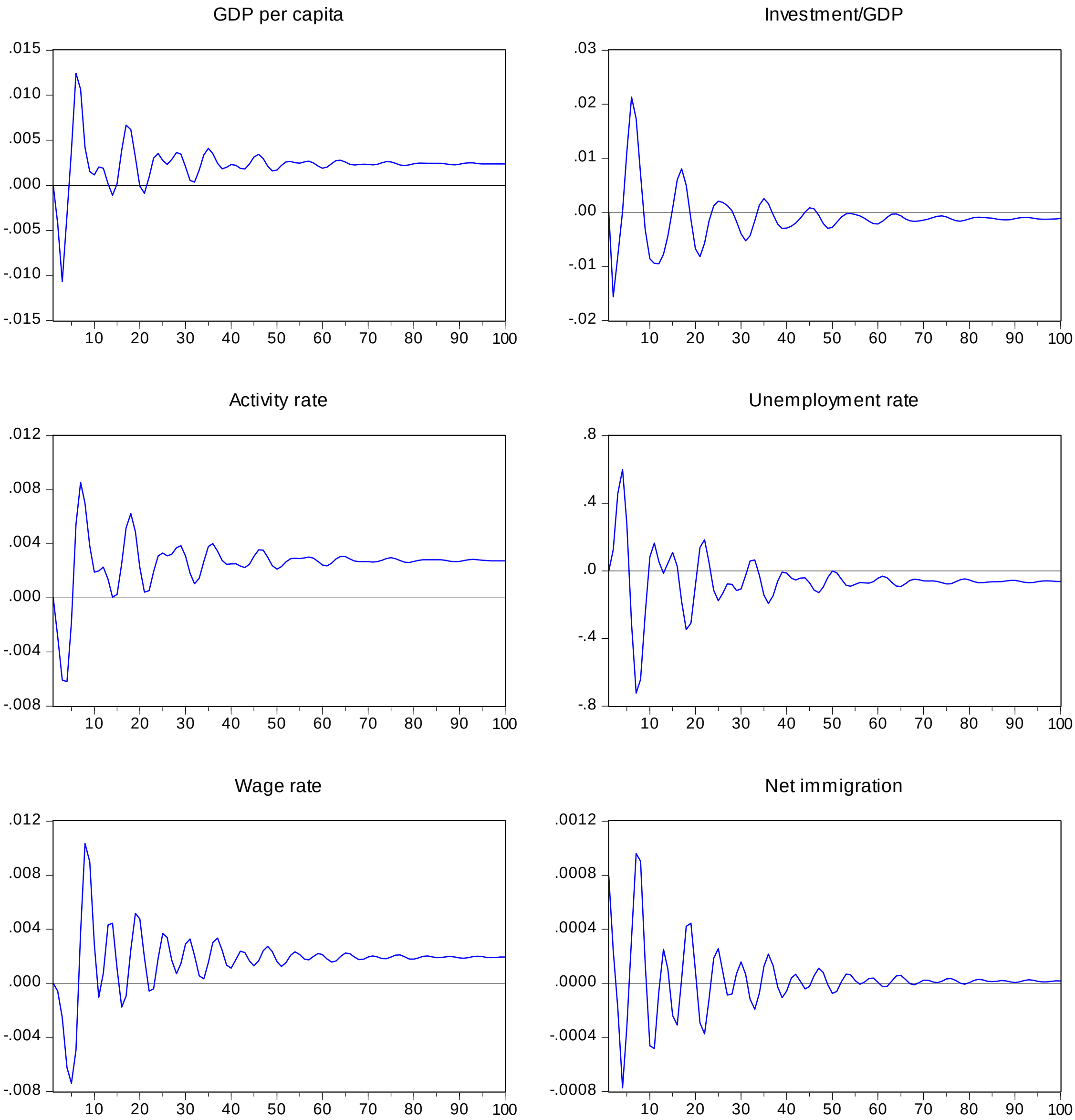
We illustrate that the working of the complete model is in line with the long-term relations (27) and (25) by applying a temporary shock to the immigration variable and looking at the impulse response. The result can be seen in Figure 6.[25] The shock equals one standard error of the regression of equation (35), 0.0008, which corresponds to 12,700 persons in addition to the present immigration, when evaluated at a constant population of 16 million inhabitants. It has a persistent though small long term effect on its own value. The long-term impact on the *L/P* ratio is 0.0027, about a quarter of a percent. In line with (25) the impact on the GDP per capita is about 0.0024 in the long run. Investment shares are slightly reduced indicating a sectoral shift to low-skill sectors in the past, when migration was allowed in order to prevent sector movements to low-wage countries. The shock to immigration can be seen as a supply shock or as a removal of a constraint on labour demand. Following the latter interpretation, hence lifting the

---

If the growth rate of immigration increases by one percentage point, that of emigration decreases by 0.24 percentage points. Together with the absence of cointegration this is a non-negligible but still weak correlation. Both procedures, using net or gross immigration seem legitimate, and lead to similar results. In that respect it is interesting to observe that van Dalen and Henkes (2011) emphasise that emigration in the Netherlands is not driven primarily by economic factors.

[25] Technically speaking this is a response to a non-factorized one standard deviation of an *NMP* innovation on: *log(y), log(I/Y), log(L/P), u, log(w)* and *NMP*.

Figure 6 Response to a transitory positive net immigration shock



constraint on labour demand, reduces long-run unemployment by 0.07 and enhances average wages by 0.002, both at fairly small amounts though. In the first four years we have a higher unemployment rate, lower wages, a lower activity rate, investment share and GDP per capita. Moreover, looking at the first ten years only it is not obvious that advantages are larger than disadvantages on net.[26] A migration policy trying to yield the long run advantages should therefore phase in additional immigration carefully.

Effects of a permanent shock in net immigration

A permanent shock on net immigration is carried out as an increase of the intercept of equation (35) from 1975 onwards. This value of $0.312*10^{-3}$ is enlarged by $0.148*10^{-3}$, where the latter is 10% of the mean of net immigration as a share of the population, *NMP*. We run two deterministic, dynamic forecasts, one without any shock (baseline) and one with a permanent shock as described above. We then show in Figure 7 the value after the shock compared to the baseline.

Figure (7a) shows that the permanent migration shock increases net immigration for the period 1975-2005, with the exception of the 2nd oil crisis year 1979.[27] Unemployment first goes up for six years and thereafter it is lower. Correspondingly, wages in Figure (7b) are first lower and then higher. Parallel with unemployment, the activity rate, *L/P*, first decreases and then increases, and GDP per capita reacts in the same way. The investment/GDP ratio first is lower as all other variables, then increases, but until 2030 it falls by almost 1%-point. All effects are fairly small, but growing over time because of the significant time trends in the estimates. The effects are also similar to those of the transitory shock, in particular in the long run – but the positive effects appear earlier under a permanent shock. Again the early negative effects might be mitigated by a careful phasing in of the shock towards its long-run level.

Long-run effects of a permanent shock in net immigration

In our analysis of a transitory shock we find clearly positive effects only after 10 years and in case of a permanent shock after seven years. However, in both cases the effects are below 2% even after 30 years. An alternative way of looking at the effect of a permanent shock in the long run is to look at the long-run implied by our empirical model.

[26] Therefore our results are in line with those of Jean and Jimenez (2011) who find no impact of immigration on unemployment for OECD countries for the period 1984-2003. Cohen-Goldner and Paserman (2004) also find a short-run fall in wages that vanishes after four to seven years for Israel 1989 – 99. They find no short or long-run effect on unemployment. Ottaviano and Peri (2009) find that average wages are falling in the short run and increasing in the long run, as we do.

[27] The average increase is $0.259*10^{-3}$ which is higher than the shock of $0.148*10^{-3}$. The reason is that the wage increase will also attract more immigrants.

Figure 7a Impact of permanent shock on net immigration and unemployment (absolute difference with base line)

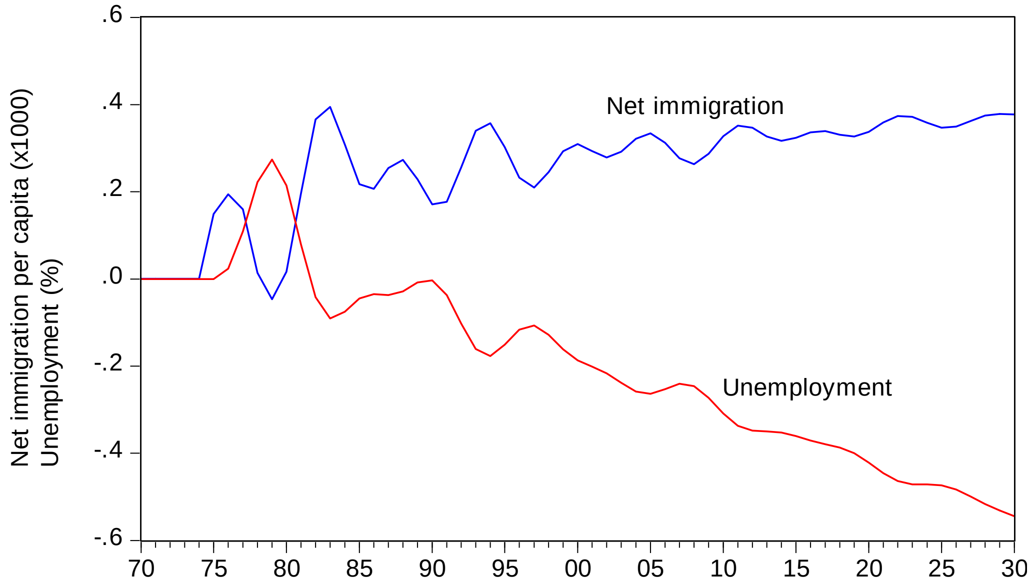
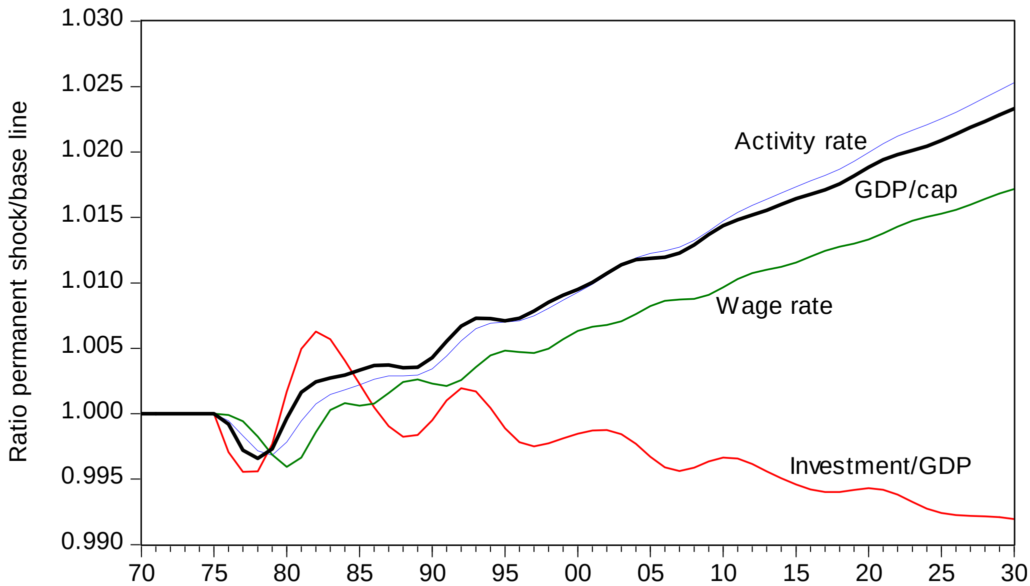


Figure 7b Impact of permanent shock on other variables (relative to base line)



The long-term relations (25)-(29) are five equations in six variables. If we assume a constant unemployment rate of *u* of 4%,[28] which is observed in the Netherlands for the more recent years, we can solve the system for the other five variables. If we increase the intercept of the solution for the net immigration rate again by 10% of the mean of net immigration, $0.148*10^{-3}$, or equivalently multiply the intercept of (28) by a factor 0.9895, the increases in the values are as follows:

d(nmp) = $0.148*10^{-3}$ or 2350 persons;
dlog(L/P) = 0.0251 (2.5%)
dlog(I/Y) = 0.0105 (1%)
dlog(w) = 0 because we keep u=4 fixed[29]
dlog(y) = 0.0217 (2.17%)

A change by 10% of the mean value of net immigration (23,500 persons) at a constant unemployment rate increases the activity rate, *L/P*, by 2.5%, the investment/GDP ratio by 1% and GDP per capita by 2.17%. This is the same order of magnitude as that of Figure 7 for a permanent shock to the whole system.

For all three types of shock assumptions more net immigration leads to a higher activity rate and a higher GDP per capita after some years. The size of these effects of course varies with the type of the shock and related assumptions. As immigration policies have been changing between more and less restrictive it is not obvious, which of our shock results is most realistic.

Finally, our shock analysis has more positive results for the level of GDP per capita the longer the period is. This is consistent with the analysis of Felbermayr et al. (2008) who find a positive impact of the stock of migrants on the rate of growth in a cross-section study. As stocks of migrants are built up over time by flows of migrants it is important to see that in the short run the results may be less clear-cut.

[28] This assumption is in line with the result by Cohen-Goldner and Paserman (2004) as well as Jean and Jimenez (2011) that immigration has no impact on unemployment and it is only a slight deviation from our result from the preceding shock analysis that unemployment reacts a little bit to immigration.

[29] Most empirical literature on the impact of immigration on wages has emphasized that the effects are at best small if not completely absent, with exceptions though especially for women, when analysing the occupational level (Friedberg and Hunt 1995; Steinhardt 2011). For a critical assessment of this position in the American debate, see Aydemir and Borjas (2011).

5.3 The impact of gross immigration on the activity rate

Our empirical model used in the above analysis is a VECM, based on a VAR that has three lags. Information on longer lags is ignored. Moreover, for policy recommendations the relevant policy variable is gross rather than net immigration because restrictive policies on immigration can be relaxed easily, but it is more difficult to have an impact on emigration. For those reasons we investigate whether or not gross immigration has a positive impact on the *L/P* ratio when more lags are allowed for.

As we want to employ many more lags than the VECM has, we re-run the VECM for gross immigration (not shown) and run a separate regression for *log(L/P)* on all variables that have an impact on it according to the equation corresponding to (32) and in addition to eleven lags of immigration per person of the population, *im/P*. Stepwise forward and backward regressions then result in a significantly positive effect of the early lags of immigration on the *L/P* ratio (not shown). However, lags seven and higher are mostly and increasingly negative. In order to get a bit more structured result we impose the assumption of a polynomial distributed lag of the third degree on the immigration variable.[30] The results for the lags of the gross-immigration/population ratio are presented in Figure 8.[31] From the ninth year after immigration onward, the impact of immigration *im/P* on the activity rate *L/P* is negative. The positive overall effect turns out to be insignificant in this regression – see Figure 8.

The result also holds if we add more lags and if we replace the polynomial of third degree by one of degree two or one, albeit at the cost of getting more serial correlation. As we estimate twelve parameters with 37 observations, this result cannot be robust to all possible other changes. Our interpretation of the finding in Figure 8 is that even if some members of an immigrant family work, there are relatively more dependents after ten years. Moreover, as we found a significantly positive coefficient of immigration in a similar regression for persons in the labour force instead of hours worked in Muysken et al. (2008), less hours worked per person after the movement of labour-intensive branches to low-wage countries might also be part of an explanation.

[30] The third degree used has the advantage that it is sufficiently flexible, while one can avoid running into serial correlation.

[31] The details for the regression are presented in Appendix 3.

Figure 8:
The impact of the lagged immigration/population ratio on the activity rate *L/P*

Lag Distribution of IM/P	lag	i	Coefficient	Std. Error	t-Statistic
.* |		0	0.13784	2.17645	0.06333
. * |		1	0.89298	1.17106	0.76254
. * |		2	1.35326	0.70032	1.93233
. *|		3	1.55648	0.64705	2.40550
. *|		4	1.54046	0.68592	2.24581
. * |		5	1.34299	0.69856	1.92252
. * |		6	1.00189	0.71325	1.40468
. * |		7	0.55496	0.75083	0.73912
* |		8	0.04001	0.77827	0.05141
* . |		9	-0.50514	0.75307	-0.67078
* . |		10	-1.04270	0.74080	-1.40754
* . |		11	-1.53485	1.06694	-1.43855
	Sum of Lags		5.33817	6.44655	0.82807

Ageing requires a higher number of active persons. Our evidence shows that it is possible to increase the activity rate by immigration for some years. However, in later years the positive impact vanishes. For immigration to be a tool to help mitigating the ageing problem the impact on the activity rate requires policy improvements. If policy can arrange immigration in a way that hours worked relative to the population increase,[32] our VECM above shows that GDP per capita can increase by about 85% of the percentage change in the hours worked per person in the population.

6. Concluding remarks

In this paper we have extended the work of Razin and Sadka (2000), Kemnitz (2003), Boeri and Brücker (2005) and Brücker and Jahn (2011) by analysing immigration in a general equilibrium context, including physical capital in a CES production function, using a right-to-manage wage bargaining model, and allowing for unemployment. The main conclusion from the theoretical model is that income per capita will increase due to immigration, under the condition that the immigrants find employment and contribute to the skill distribution at least proportionally to the native population. The increase in capital accumulation following immigration, turns out to be an additional determinant of economic growth when analysing the benefits of immigration.

[32] See for example OECD (2008, Ch. 5) for considerations on improvements of immigration policies.

Our empirical analysis for the Netherlands reveals that at least hours worked relative to the population must increase in order to get a positive impact of immigration on the economy. Thus to stimulate economic growth it is of utmost importance that immigration policy as a means to mitigate the aging problem should not only focus on the number of immigrants, but also on their employability by keeping the skill structure in line with the skill distribution of domestic labour market entrants. This requires two steps: (1) skill neutral admission of immigrants and (2) an education policy that has the ambition and ability to educate the second and third generations of immigrants, at least in line with the average skill distribution in a country.

Our conclusions support the view of the European Commission that immigrants in general have a positive impact on the economy provided that they are employed. As the European Commission puts it: “the current situation and prospects of EU labour markets can be broadly described as a ‘need’ scenario. Some Member States already experience substantial labour and skills shortages in certain sectors of the economy, which cannot be filled within the national labour markets. This phenomenon concerns the full range of qualifications - from unskilled workers to top academic professionals.” (EU, 2005, p. 4).[33] In line with this statement by the European Commission we argue, following our theoretical and empirical results, that the immigration policy of the European Union with respect to the blue card and the admission of some other specific groups is too restrictive to maximise the benefits from immigration in the light of an ageing population.

Finally, the expectations from immigration as a single cure for falling birth rates and an ageing population should not be too high, since it is only one policy instrument within a broader mix and it has only small effects as shown in our empirical analysis. Many countries in the European Union should worry about their high unemployment and low employment rates, and give more priority to increase employment. However, our analysis shows a slightly positive effect of immigration on employment after some years. Immigration policies should go hand in hand with active labour market policies and education policies to get the low-skilled unemployed back to work and to prevent young

[33] More recent EU policy views are less optimistic on the positive impact of migration as is surveyed in Koehler cs. (2010). However, in line with Koehler et al., we think that position is too pessimistic and reflects a defensive reaction in response to the recent crisis.

people, both natives and immigrants, from early school leaving, thereby raising their level of education and opportunities on the labour market – see also OECD (2008).

References

Aydemir, A., G.J. Borjas (2011), Attenuation Bias in Measuring the **Wage** Impact of Immigration , *Journal of Labor Economics*, January 2011, v. 29, iss. 1, pp. 69-112.

Ben-Gad, M. (2008), Capital-skill complementarity and the immigration surplus, *Review of Economic Dynamics*, 11, 335-365.

Boeri, T. and H. Brücker (2005), European migration, *Economic Policy*, 44, 629 – 703.

Boubtane, E. and J.C. Dumont (2010), immigration and economic growth in the OECD countries 1986-2006: A panel data analysis; mimeo.

Brücker, H. and E. Jahn (2011), Migration and Wage-Setting: Reassessing the Labor Market Effects of Migration, *Scandinavian Journal of Economics*, forthcoming.

Casarico, A. and C. Devillanova (2003), Social Security and Migration with Endogenous Skill Upgrading, *Journal of Public Economics* 87(3-4), 773-797.

Cohen-Goldner, S. and D. Paserman (2004), The dynamic Impact of Immigration on Natives'Labour Market Outcomes: Evidence from Israel, CEPR Discussion paper No. 4640.

Dalen, H.P. van, and K. Henkens, 2011, *Why Leave a High-Income Country? The Case of Dutch Emigrants*, working paper NIDI, The Hague.

Davidson, R. and J.G. MacKinnon (2004), Econometric Theory and Methods, Oxford University Press, New York, Oxford.

EU (2005), *Policy Plan on Legal Migration*, COM (2005) 669 final, Brussels.

Felbermayr, G.J., S. Hiller and D. Sala (2008). Does Immigration Boost Per Capita Income? Hohenheimer diskussionsbeiträge No. 300.

Freeman, R.B. (2006), *Is a great labour shortage coming? Replacement demand in the global economy*, NBER Working Paper No. 12541, New York.

Friedberg, R.M. and J. Hunt (1995), The Impact of Immigrants on Host Country Wages, Employment and Growth. The Journal of Economic Perspectives, Vol. 9, No.2, 23-44.

Gómez, R. and P. Hernández de Cos (2008), Does population ageing promote faster economic growth?, *Review of Income and Wealth*, 54 (3), 350-372.

Feyrer J. (2007), Demographics and Productivity, *Review of Economics and Statistics*, 89 (1), 100-109.

Holinski N., C. Kool and J. Muysken (2009a), International Portfolio Balance – Modeling the External Adjustment Process, *Meteor Research Memorandum* 2009-033.

Holinski N., C. Kool and J. Muysken (2009b), Taking Home Bias Seriously: Absolute and Relative Measures Explaining consumption Risk-sharing, *Meteor Research Memorandum* 2009-035(RM/08/025-revised).

Huber, P., M. Landesmann, C. Robinson and R. Stehrer (2010), Migrants' Skills and Productivity: A European Perspective, *National Institute Economic Review*, No 213, 20-34.

Jean, S. and M Jimenez (2011), The unemployment impact of immigration in OECD countries, *European Journal of Political Economy* 27, 241-256.

Jones, C.I. (1995), R&D-Based Models of Economic Growth, Journal of Political Economy, Vol. 105, no.4, 759-783.

Kemnitz, A. (2003), Immigration, Unemployment and Pensions, *Scandinavian Journal of Economics*, 105 (1), 31-47.

Kim, Y., P. Levine and E. Lotti (2010), Migration, Skill Composition and Growth, *National Institute Economic Review*, No 213, 5-19.

Koehler, J., Laczko F., Aghazarm C. and J. Schad (2010), *Migration and the Economic Crisis in the European Union: Implications for Policy,* International Organization for Migraton, IOM Thematic Study.

Krieger, T. (2004), Fertility rates and skill distribution in Razin and Sadka's migration-pension model: A note, *Journal of Population Economics,* 17, 177–182.

Lindh, T. and B. Malmberg (2009), European Union economic growth and the age structure of the population, *Econ Change Restruct*, 42, 159-187.

Mankiw, N.G., D. Romer, D.N.Weil (1992), A Contribution to the Empirics of Economic Growth, The Quarterly Journal of Economics, May, 407-437.

Mondria J. and T. Wu (2010), The Puzzling Evolution of the Home Bias, Information Processing and Financial Openness, *Journal of Economic Dynamics and Control*, 34 (5), 875-96.

Morley, B. (2006), Causality between economic growth and immigration: An ARDL bounds testing approach, Economics Letters 90, 72-76.

Müller, T. (2003), Migration, Unemployment and Discrimination, *European Economic Review* 47(3), 409-427.

Münz, R. (2009), *Demographic Change, Labour Force Development and Migration in Europe – Current Situation, Future Outlook and Policy Recommendations* in: Swedish EU Presidency, pp. 6-11.

Muysken, J., F. Cörvers and T. Ziesemer (2007), Immigratie als wapen in de strijd tegen de vergrijzing, *Kwartaalschrift Economie*, 4 (4), 475 – 496.

Muysken J., F. Cörvers and T. Ziesemer (2008), Immigration can alleviate the ageing problem, *Meteor Research Memorandum* 2008-004.

Muysken J. and T. Ziesemer (2011a), Immigration and growth in an ageing economy, UNU-MERIT Working Paper 2011-012.

Muysken J. and T. Ziesemer (2011b), Immigration and growth in an ageing economy - version 2, UNU-MERIT Working Paper 2011-037.

Nannestad, P. (2007), Immigration and welfare states: A survey of 15 years of research, *European Journal of Political Economy,* 23 (2), 512-532.

OECD (2008),

Ortega, F. and G. Peri (2009), The Causes and Effects of International Migrations: Evidence from OECD Countries 1980-2005, NBER WP 14833, April.

Ottaviano, G.I.P. and G. Peri (2008), Immigration and National Wages: Clarifying the theory and the Empirics, CEPR DP 6916, July.

Papageorgiou, C. and M. Saam (2008), Two-level CES Production Technology in the Solow and Diamond Growth Models, *The Scandinavian Journal of Economics*, 110 (1), 119-143.

Parkes, R. and S. Angenendt (2010), *After the Blue card EU Policy on Highly qualified Migration: Three ways out of the Impasse,* Heinrich Böll Stiftung Discussion Paper, February 2010.

Patterson, K. (2000), An Introduction to Applied Econometrics: A Time-Series Approach. Palgrave Macmillan, Houndsmill and New York.

Razin, A. and E. Sadka (1999), Migration and Pension with International Capital Mobility, *Journal of Public Economics*,74(1), 141-150.

Razin, A. and E. Sadka (2000), Unskilled Migration: A Burden or a Boon for the Welfare State?, *Scandinavian Journal of Economics*, 102(3), 463-479.

Rivera-Batiz, L.A. and D. Xie, 1993, Integration among unequals, Regional Science and Urban Economics 23, 337-354.

Steinhardt, M.F. (2011), The Wage Impact of immigration in Germany – New Evidence for Skill Groups and Occupations. The B.E. Journal of Economic Analysis & Policy, Vol 11, issue 1, Article 31, 1-33.

United Nations (2000), *Replacement Migration: Is it a Solution to Declining and Aging Populations?*, UN Population Division, New York.

Vandenberghe, V. and F. Waltenberg (2010), Ageing Workforce, Productivity and Labour costs of Belgian Firms, *Institut de Recherches Économiques et Sociales de l'Université Catholique de Louvain*, Discussion Paper 2010-3, 1-30.

Werding, M. (2008), Ageing and Productivity Growth: Are there macro-level Cohort effects of Human Capital, *CESifo Working paper*, No. 2207, 1-38.

Appendix 1 The data used

Variable	Source	Definition
w	KLEMS;	Real wage (Labour compensation per hour worked deflated by GDP deflator 2000). This series is only available till 2007.
P	WDI	Population (mid-year)
y	WDI	GDP pc
I/Y	WDI	Gfcf/GDP
L	WDI	Labour force. total
u	CPB	Unemployment rate; international definition
EMPFTE	CPB	Employment in full-time equivalents
hours	CPB	Working hours of a full-time employee (in hours/year)
im	CBS	Immigration
Em	CBS	Emigration

CBS: Statline, http://statline.cbs.nl/StatWeb/dome/default.aspx

CPB: CEP, 2011, http://www.cpb.nl/en/publication/central-economic-plan-2011

KLEMS: EU KLEMS Productivity Report: http://www.euklems.net

WDI: World Development Indicators, Worldbank

Appendix 2 Wage bargaining, union behavior and social equilibrium

For low-skilled workers the wage is determined by union bargaining, where the unions take both the employment of high-skilled workers, which follows from labour supply, and the capital stock as given. We assume a right-to-manage model, where the bargaining power by unions equals ε – this encompasses Kemnitz' (2003) monopoly union model by setting $\varepsilon = 1$, and Razin and Sadka's (2000) full competition when $\varepsilon = 0$. Denoting the level of unemployment benefits by b and assuming a tax rate t_u, the expected income of a low-skilled worker is $(1 - u).t_u.w_L + u.b$, where u is the low-skilled unemployment rate, $u = (N_L - L)/N_L$. The firm negotiates with the unions about the wage, given its capital stock and employment of high skilled workers. The resulting wage then is found by maximising:[34]

$$\Omega = \left[L.w_L(1-t_u)+(N_L-L).b\right]^{\varepsilon}.\left[Y-w_L.L\right]^{1-\varepsilon} \qquad 0 < \varepsilon \leq 1 \qquad \text{(A1)}$$

with respect to w_L, subject to equation (3a), and given K and H. This yields:[35]

$$w_L = \frac{\varepsilon.\sigma/\psi(w_L)-(1-\varepsilon).u/(1-u)}{1+\varepsilon.(\sigma-1)/\psi(w_L)}.\frac{b}{1-t_u} \qquad \text{with} \qquad \psi(w_L) = \left[\frac{w_L}{\lambda}\right]^{1-\sigma} \qquad \text{(A2)}$$

where $\psi(w_L)$ is the low-skilled labour share in income as a function of the low-skilled wage, and $\psi'(w_L) < 0$ when $\sigma > 1$.[36]

Equation (A2) cannot be solved explicitly for w_L, due to the non-linear nature of $\psi(w_L)$. For that reason we use a linear approximation of the first part of the right hand side, such that:

$$w_L = \left[\frac{\varepsilon.\sigma/\lambda'-(1-\varepsilon).u/(1-u)}{1+\varepsilon.(\sigma-1)/\lambda'}\right].\frac{b}{1-t_u} - \varepsilon.\nu.(\sigma-1).w_L \qquad \text{(A3)}$$

---

[34] See also Boeri and van Ours (2008, pp. 58 *ff.*).

[35] This is consistent with Kemnitz' (2003) result when we assume a monopoly union and a Cobb-Douglas function, i.e. $\varepsilon = 1$ and $\sigma = 1$.

[36] We assume $\psi(w_L) > -\varepsilon.(\sigma-1)$ which always does hold for $\sigma \geq 1$.

does hold, where $v > 0$ is a constant and $\lambda' = \lambda^{1-\frac{1}{\sigma}}$. This reproduces the important properties of the right hand side of (A2) following from $\psi'(w_L) < 0$ when $\sigma > 1$, $\psi(w_L)$ approximates 1 when σ decreases towards 1 and $\psi(w_L)$ increases when λ increases. The wage rate then is given by:[37]

$$w_L = \frac{\varepsilon.\sigma - (1-\varepsilon).\lambda'.u/(1-u)}{[1+\varepsilon.v.(\sigma-1)].[\lambda'+\varepsilon.(\sigma-1)]}.\frac{b}{1-t_u} \tag{A4}$$

Thus the negotiated low-skilled wage is a mark-up on the benefit level, which decreases with an increase in unemployment u as seems plausible. Both a fall in the tax rate, t_u, and a rise in low-skilled labour augmenting productivity, λ, will decrease the mark-up. It is also interesting to note that a decrease in the elasticity of substitution leads to a higher mark-up, since in that case it is more difficult for low-skilled labour to take over the role of high-skilled labour.

Social equilibrium requires that the employed pay taxes at a rate t_u to finance their unemployed colleagues. We assume a pay-as-you-go system where government sets the tax and benefit rates such that unemployment benefits are covered by tax revenues. Since we focus on low-skilled unemployment, we assume that the benefits are paid by taxes on the low-skilled wage only.[38] That is, given a certain level of benefits b, consistency with a tax rate t_u requires:

$$t_u.w_L.L = b.(N_L - L) \tag{A5}$$

One should realise that either the tax rate t_u or the benefit level b is endogenous. Kemnitz (2003) assumes the tax rate t_u to be determined a priori by government. However, in line with the approach more commonly used in the literature – e.g. for instance Boeri and

[37] Again, this is consistent with Kemnitz' (2003) result when we assume a monopoly union and a Cobb-Douglas function, i.e. $\varepsilon = 1$ and $\sigma = 1$. Since he assumes a monopoly union, Kemnitz finds no impact of unemployment on the mark-up.

[38] This assumption, which is in line with Kemnitz (2003), is motivated by analytical tractability. Including benefits paid by high skilled workers complicates the analysis considerably, without altering the qualitative results.

Brücker (2005) – we assume that government sets a replacement rate β with respect to the *net* wage, and then derives the tax rate from substituting $b = \beta.(1- t_u).w_L$ in equation (A5).[39,40]

When setting the replacement rate at β, we find from equation (A5) that the equilibrium rate of unemployment u^* is given by:[41]

$$u^* = 1 - \frac{1}{1+\Psi} \quad with \quad \Psi = \frac{\beta.\varepsilon.\sigma - [1+\varepsilon.\nu.(\sigma-1)].[\lambda' + \varepsilon.(\sigma-1)]}{(1-\varepsilon).\lambda'.\beta} \qquad (4)$$

[39] This approach would not work in the analysis of Kemnitz (2003), since he finds no impact of unemployment on the mark-up due to his assumption of a monopoly union.

[40] We assume that unions respect the choice of government of a fixed replacement rate, i.e. they don't exploit it and therefore it is not included as an additional constraint on the maximisation problem of equation (4).

[41] A similar equation is used by Boeri and Brücker (2005), although they introduce this equation ad hoc.

Appendix 3 Asset and capital stock dynamics under home asset preference and perfect capital markets

The basic equations are (17) - (19). They can be rewritten as

$$K = (1 - \lambda)\mu A + \lambda K^* \tag{17}$$

$$A = A_{-1}/d + (rK^* - rK + fK)/d \qquad \text{with } d \equiv 1 - [T\varphi r - \xi(1-\varphi)] \text{ and } f = T\alpha^* r \tag{18}$$

$$K^* = (1+a+n)K^*_{-1} \tag{19}$$

This is a system of three difference equations in *A*, *K*, and *K**. In order to transform it into one equation in $b \equiv A/K^*$, we define $k \equiv K/K^*$. Dividing both sides of (18) by K^* and multiplying and dividing the first term by K^*_{-1} and using (19) yields

$$b = b_{-1}\frac{1}{a+n+1}\frac{1}{d} + \frac{r-rk+fk}{d} \tag{19'}$$

Dividing both sides of (18) by K^* yields

$$k = (1 - \lambda)\mu b + \lambda \tag{18'}$$

Insertion of (18') into (19') yields a difference equation in *b*:

$$b = b_{-1}\frac{1}{a+n+1}\frac{1}{d} + \frac{r+(f-r)(r(1-\lambda)\mu b + \lambda)}{d}$$

Putting b-terms to the left-hand side leaving its lag on the right-hand side yields

$$b = b_{-1}\frac{1}{(a+n+1)(d-\mu(1-\lambda)(f-r))} + \frac{r+(f-r)\lambda}{d-\mu(1-\lambda)(f-r)}$$

This equation can be drawn with *b* on the vertical axis and b_{-1} on the horizontal axis. Realistic cases have a positive and constant long-run value of $b = A/K^* > 0$. This requires a negative or positive slope that is below unity and a positive intercept. We discuss three special cases, two of which fulfill this requirement:

(i) The special case $\lambda=1$ of efficient capital $K=K^*$, has an intercept $f/d>0$ and a slope $1/[(a+n+1)d]$, with $d>1$ as the expression $T\varphi r$ in (18) is a product of four percentage expressions all smaller than unity. Other cases can be constructed but they also hold without $\lambda=1$ and are discussed below.

(ii) A second special case is $f=r$. The interpretation of f is savings of wage income after taxes and pension premiums per unit of capital. The slope is as in the previous case and the intercept is r/d, which are both positive in non-inflationary times of positive real interest rates.

(iii) Amano's (1965) case of negative and increasing net-foreign debt D: $D/K\equiv (K-A)/K=1 - A/K <0$ requires a permanently positive growth of $A/K=(A/K^*)/(K/K^*) =b/k$. together with equation (18') implies that $k/b = (1 - \lambda)\mu + \lambda/b$ should fall permanently, but it has a limit of $(1 - \lambda)\mu$ .When $\mu = 0$ and b going to infinity we find the minimum value of k/b = 0, then b/k is infinity. This requires a positive intercept and a slope larger than unity.

(iv) A constant ratio $D/K \equiv (K-A)/K \equiv 1-A/K > (<) 0$, requires a constant $A/K=(A/K^*)/(K/K^*)=b/k$. According to (18') this also requires a constant b.

For our case of aging and immigration only cases of constant b are relevant. If b goes to a constant value it follows from (18') that $k=K/K^*$ goes to a constant value. By implication $b/k=A/K$ also go to a constant value. If b is constant, then A and K^* grow at the same rate and K must have the same rate as well, which is $a + n$.

We are in particular interested in the impact of the rate of contribution t_p on the growth rate. Higher pension premiums t_p lead to lower values of f and higher values of d. (The interpretation of f is savings of wage income after taxes and pension premiums per unit of capital.) Higher values of d lead to a lower value of the slope and of the intercept and therefore to lower growth rates. Lower values of f go in the same direction. Higher premiums therefore reduce the private assets to efficient capital ratio, A/K^*. According to equation (18') capital growth is above $a + n$ to the extent that A/K^* is growing. Therefore capital also has a growth rate that is falling with t_p.

Appendix 4 Estimation results for section 5

First and second lags of first-differenced variables of the vector-error-correction model (t-values in brackets)

Equation	(34)	(35)	(36)	(37)	(38)	(39)
Variables						
Indep.\dep.	D(LNGDPPC)	D(LOG(I/Y))	D(LOG(L/P))	D(U)	D(LOG(W))	D(NMP)
D(LNGDPPC$_{-1}$)	-0.452073	0.019547	-0.335577	22.11674	-0.712145	-0.013503
	[-0.97909]	[0.03084]	[-1.30302]	[2.09569]	[-1.65513]	[-0.46714]
D(LNGDPPC$_{-2}$)	-0.235111	0.577541	0.075202	4.249184	-0.589942	-0.013713
	[-0.74270]	[1.32895]	[0.42591]	[0.58728]	[-1.99988]	[-0.69196]
D(LOG(I/Y)$_{-1}$)	-0.482689	-0.684197	-0.150132	5.940609	0.15168	-9.27E-03
	[-2.79059]	[-2.88132]	[-1.55613]	[1.50263]	[0.94104]	[-0.85646]
D(LOG(I/Y)$_{-2}$)	-0.144334	-0.135353	0.044517	-2.84233	0.097732	0.000531
	[-1.08621]	[-0.74198]	[0.60065]	[-0.93586]	[0.78928]	[0.06384]
D(LOG(L/P)$_{-1}$)	0.1176	1.493333	0.640141	-31.08595	0.476419	0.013915
	[0.22417]	[2.07347]	[2.18767]	[-2.59249]	[0.97454]	[0.42368]
D(LOG(L/P)$_{-2}$)	-1.419593	-0.849959	-0.584379	27.75422	0.392533	0.042969
	[-2.71481]	[-1.18401]	[-2.00362]	[2.32219]	[0.80557]	[1.31264]
D(U$_{-1}$)	-0.034419	-0.04171	-0.01044	0.533122	-0.000217	0.000311
	[-3.01370]	[-2.66023]	[-1.63884]	[2.04228]	[-0.02039]	[0.43429]
D(U$_{-2}$)	-0.01084	-0.02657	0.00139	-0.092754	-0.001974	-2.69E-05
	[-1.20090]	[-2.14415]	[0.27600]	[-0.44957]	[-0.23465]	[-0.04756]
D(LOG(W$_{-1}$))	0.048674	0.424975	0.071961	-4.475284	0.333039	0.016525
	[0.25006]	[1.59035]	[0.66281]	[-1.00591]	[1.83608]	[1.35616]
D(LOG(W$_{-2}$))	0.427066	0.90451	0.289818	-15.85621	0.045598	-0.000679
	[2.00025]	[3.08592]	[2.43367]	[-3.24924]	[0.22919]	[-0.05076]
D(NMP$_{-1}$)	-2.397839	-11.52248	-1.4928	-139.6183	1.79137	0.522292
	[-0.58667]	[-2.05353]	[-0.65482]	[-1.49454]	[0.47034]	[2.04126]
D(NMP$_{-2}$)	-6.316793	-5.390569	-1.288568	21.44815	-2.004672	0.175093
	[-1.62345]	[-1.00916]	[-0.59374]	[0.24117]	[-0.55289]	[0.71882]
C	0.016944	-0.048369	-0.003578	-0.070781	0.039759	0.000321
	[1.36349]	[-2.83531]	[-0.51624]	[-0.24921]	[3.43346]	[0.41264]

The details for the regression underlying Figure 8 are as follows.

Dependent Variable: log(L/P). Method: Least Squares. Period: 1973-2009. HAC standard errors & covariance (Bartlett kernel, Andrews bandwidth = 0.8746)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.411231	0.344680	-4.094324	0.0004
LOG(L(-1)/P(-1))	0.809340	0.060230	13.43750	0.0000
D(LOG(IY(-1)))	0.109717	0.051083	2.147826	0.0416
D(LOG(IY(-2)))	0.201977	0.044276	4.561820	0.0001
LNGDPPC(-1)	0.084866	0.018631	4.555228	0.0001
D(LNGDPPC(-2))	0.210145	0.133543	1.573618	0.1281
LOG(IY(-1))	0.146983	0.054929	2.675857	0.0130
D(LOG(L(-2)/P(-2)))	-0.765533	0.202438	-3.781568	0.0009
PDL01	1.342988	0.698558	1.922515	0.0660
PDL02	-0.275587	0.240278	-1.146951	0.2623
PDL03	-0.071817	0.061504	-1.167675	0.2540
PDL04	0.006301	0.013445	0.468690	0.6434

Adjusted R-squared: 0.97. Durbin-Watson stat: 1.73.

The UNU-MERIT WORKING Paper Series

2011-01 *Mitigating 'anticommons' harms to research in science and technology* by Paul A. David
2011-02 *Telemedicine and primary health: the virtual doctor project Zambia* by Evans Mupela, Paul Mustard and Huw Jones
2011-03 *Russia's emerging multinational companies amidst the global economic crisis* by Sergey Filippov
2011-04 *Assessment of Gender Gap in Sudan* by Samia Satti Osman Mohamed Nour
2011-05 *Assessment of Effectiveness of China Aid in Financing Development in Sudan* by Samia Satti Osman Mohamed Nour
2011-06 *Assessment of the Impacts of Oil: Opportunities and Challenges for Economic Development in Sudan* by Samia Satti Osman Mohamed Nour
2011-07 *Labour Market and Unemployment in Sudan* by Samia Satti Osman Mohamed Nour
2011-08 *Social impacts of the development of science, technology and innovation indicators* by Fred Gault
2011-09 *User innovation and the market* by Fred Gault
2011-10 *Absorptive capacity in technological learning in clean development mechanism projects* by Asel Doranova, Ionara Costa and Geert Duysters
2011-11 *Microeconomic analysis of rural nonfarm activities in the Kyrgyz Republic: What determines participation and returns?* By Aziz Atamanov and Marrit van den Berg
2011-12 *Immigration and growth in an ageing economy* by Joan Muysken and Thomas Ziesemer
2011-13 *State-led technological development: A case of China's nanotechnology development* by Can Huang and Yilin Wu
2011-14 *A historical perspective on immigration and social protection in the Netherlands* by Melissa Siegel and Chris de Neubourg
2011-15 *Promoting return and circular migration of the highly skilled* by Metka Hercog and Melissa Siegel
2011-16 *Voluntary agreements and community development as CSR in innovation strategies* by Vivekananda Mukherjee and Shyama V. Ramani
2011-17 *Strengthening the roles of political parties in Public Accountability - A case study of a new approach in political party assistance* by Renée Speijcken
2011-18 *The elusive quest for the golden standard: Concepts, policies and practices of accountability in development cooperation* by Renée Speijcken
2011-19 *Are health care payments in Albania catastrophic? Evidence form ALSMS 2002, 2005 and 2008* by Sonila Tomini and Truman G. Packard
2011-20 *On India's plunge into Nanotechnology: What are good ways to catch-up?* By Shyama V. Ramani, Nupur Chowdhury, Roger Coronini and Susan Reid
2011-21 *Emerging country MNEs and the role of home countries: separating fact from irrational expectations* by Rajneesh Narula and Quyen T.K. Nguyen
2011-22 *Beyond knowledge brokerage: An exploratory study of innovation intermediaries in an evolving smallholder agricultural system in Kenya* by Catherine W. Kilelu, Laurens Klerkx, Cees Leeuwis and Andy Hall
2011-23 *Dynamics of biosciences regulation and opportunities for biosciences innovation in Africa: Exploring regulatory policy brokering* by Ann Kingiri and Andy Hall

2011-24 *The when and where of research in agricultural innovation trajectories: Evidence and implications from RIU's South Asia projects* by Vamsidhar Reddy, T.S., Andy Hall and Rasheed Sulaiman V.

2011-25 *Innovation and Diffusion of Clean/Green Technology: Can Patent Commons Help?* By Bronwyn H. Hall and Christian Helmers

2011-26 *Technology alliances in emerging economies: Persistence and interrelation in European firms' alliance formation* By Rene Belderbos, Victor Gilsing, Jojo Jacob

2011-27 *Innovation pathways and policy challenges at the regional level: smart specialization* By René Wintjes and Hugo Hollanders

2011-28 *Innovation and productivity* by Bronwyn H. Hall

2011-29 *Mapping the interdisciplinary nature and co-evolutionary patterns in five nano-industrial sectors* by Lili Wang and Ad Notten

2011-30 *Assessment of industrial performance and the relationship between skill, technology and input-output indicators in Sudan* by Samia Satti Osman Mohamed Nour

2011-31 *Assessment of skill and technology indicators at the macro-micro levels in Sudan* by Samia Satti Osman Mohamed Nour

2011-32 *Education, training and skill development policies in Sudan: Macro-micro overview* by Samia Satti Osman Mohamed Nour

2011-33 *Estimating the rate of return to education in Sudan* by Samia Satti Osman Mohamed Nour

2011-34 *The importance (impact) of knowledge at the macro-micro levels in Sudan* by Samia Satti Osman Mohamed Nour

2011-35 *Angus Maddison and Development Economics* by Adam Szirmai

2011-36 *Managerial ownership and urban water utilities efficiency in Uganda* by Dorcas Mbuvi and Achraf Tarsim

2011-37 *Immigration and growth in an ageing economy* by Joan Muyskens and Thomas Ziesemer

2011-38 *The Development of Diaspora Engagement Policies in Burundi and Rwanda* by Sonja Fransen & Melissa Siegel

2011-39 *Understanding the changing role of the Turkish diaspora* by Özge Bilgili & Melissa Siegel

2011-40 *Understanding Ethiopian diaspora engagement policy* by Katie Kuschminder and Melissa Siegel

2011-41 *Engaging the diaspora in India* by Metka Hercog and Melissa Siegel

2011-42 *Protecting Vulnerable Families in Central Asia: Poverty, vulnerability and the impact of the economic crisis* by Franziska Gassmann

2011-43 *Innovation performance and embeddedness in networks: evidence from the Ethiopian footwear cluster* by Mulu Gebreeyesus and Pierre Mohnen

2011-44 *The power of the strong state: A comparative analysis of the diaspora engagement strategies of India and Ethiopia* by Katie Kuschminder and Metka Hercog

2011-45 *New insights on the role of location advantages in international innovation* by Rajneesh Narula and Grazia D. Santangelo

2011-46 *Preferences for conditioning and being conditioned - experimental & survey evidence from Zambia* by Esther Schüring

2011-47 *International migration and local employment: analysis of self-selection and earnings in Tajikistan* by Aziz Atamanov and Marrit van den Berg

2011-48 *Complementarity between in-house R&D and technology purchasing: evidence from Chinese manufacturing firms* by Jun Hou and Pierre Mohnen
2011-49 *The internationalization of R&D* by Bronwyn H. Hall
2011-50 *Missing the target: Lessons from enabling innovation in South Asia* by Sulaiman V. Rasheed , Andy Hall and T.S. Vamsidhar Reddy
2011-51 *Optimal public investment, growth, and consumption: Evidence from African countries* by Augustin Kwasi Fosu, Yoseph Yilma Getachew and Thomas Ziesemer
2011-52 *Size, competition, and innovative activities: a developing world perspective* by Abdul Waheed
2011-53 *What Changes Gini Coefficients of Education? On the dynamic interaction between education, its distribution and growth* by Thomas Ziesemer
2011-54 *Global Framework for differential pricing of pharmaceuticals* by Rutger Daems and Shyama V. Ramani
2011-55 *The effect of net immigration on economic growth in an ageing economy: transitory and permanent shocks* by Joan Muysken and Thomas Ziesemer