Interaction of Regional Population and Employment over Time: identifying short-run effects and equilibrium adjustment

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Abstract:

We investigate the interaction of regional population and employment in a simultaneous model. A focus on regional time series allows us to innovate in two ways on the ongoing causality debate in the literature. Firstly, a dynamic specification is proposed that generalizes the often assumed lagged adjustment process and enables to identify both short and long-term effects. We argue that the long-run relationship between population and employment should be interpreted as a labour market equilibrium. A second improvement on current empirical evidence is the use of region and time-specific fixed effects. Because by applying these panel data techniques, unobserved heterogeneity on the regional level and national trends are controlled for, the identification of regional population-employment interaction is substantially less troubled by an omitted variables problem. The model is estimated on almost three decades of annual data for regions in The Netherlands. This dataset is unique because it includes internal migration, so that we can disentangle net migration and exogenous natural population increase in order to model population adjustment more accurately. Reflecting the geographical structure of the country, which is characterised by overlapping urban areas, we allow for interregional commuting. Our main findings are that in The Netherlands, employment growth responds to deviations from regional labour market equilibria, but net internal migration is only slightly affected by regional employment in the short run. This implies that equilibrium on regional labour markets is restored through adjustment of employment instead of population. It also illustrates the additional insight into dynamic adjustment processes that can be gained from distinguishing both short and long-run effects, the importance of which is confirmed by rejection of the lagged adjustment process hypothesis for our data. Finally, the dominance of supply side factors in the employment equation casts doubt on appropriateness of traditional regional export base and multiplier models, which heavily rely on the assumption that local factor supply constraints are absent.

1. Introduction

There is nowadays a large literature on the spatial interaction of population and employment, both on urban and regional scale. It has been recognised that labour and consumer markets are among the essential mechanisms that lead local population and employment to adjust to one another. From a theoretical point of view, the interaction of population and employment would be simultaneous. However, it is fair to say that theoreticians have usually started from the idea that employment is exogenous to population. In particular in the urban economic literature, the monocentric model introduced by Alonso (1964) that presumes employment is exogenously located in the Central Business District has become standard. Furthermore, regional economic text books usually emphasize the importance of the export base, regional multipliers and input-output linkages. A fundamental presumption in these more traditional theories is that there are no restrictions on factor supply, and thus that regional population or labour supply adjusts to demand. Instead, they focus on demand side factors like international trade. The idea that population is exogenous to employment has always been less attractive to economic theory. Exceptions include Borts and Stein (1964), who where among the first to argue that it is labour supply, and therefore regional population, that determines employment rather than demand.

To resolve the issue empirically, simultaneous equations models for population and employment have been estimated both at he regional level (e.g. Muth, 1971, Greenwood and Hunt, 1984, and Carlino and Mills, 1987) and for urban economies (e.g. Steinnes, 1977, 1982, Steinnes and Fisher, 1974, Greenwood, 1980, and Boarnet, 1994a, b). In urban economies, population growth in one area may affect employment growth in another, because of commuting[1]. Therefore, spatial relations should be modelled explicitly at this level. Commuting has first been introduced in the Steinnes model, and elaborated upon by Boarnet (1994a, 1994b). Numerous studies have estimated variants of this model for different periods, regions and spatial aggregation levels (see e.g. Bollinger and Ihlanfeldt, 1997, Henry et al. 1997, Henry et al. 1999 and Schmitt and Henry, 2000). Most of these studies reject exogeneity of employment, and therefore provide support for the Borts and Stein hypothesis.

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[1] In regional analyses, commuting is often less important. Instead, population would adjust to employment through migration at this level.

Analysing the spatial interaction of population and employment in the spirit of Boarnet (1994a, b), this paper innovates on the dynamic analysis of this interaction. Following Treyz et al. (1993), who propose a dynamic simultaneous model for migration and employment growth in the US, we distinguish between short and long-term effects. Unlike their analyses however, our model is appropriate for investigating the interaction at an intrametropolitan scale, because interregional commuting is accounted for. This extends the current urban economic literature, which generally assumes lagged adjustment dynamics as introduced by Steinnes and Fisher (1974). Crucially, such a dynamic specification does not distinguish short and long-run effects. We show that our model generalizes this dynamic specification, and test its appropriateness for our data.

We contend that the distinction between short and long-term effects is meaningful, yielding substantive insights into adjustment processes on regional labour markets. Formulated as a simultaneous error correction model, the model we derive measures both the instantaneous interaction of population and employment growth and their response to deviations from a long-run relationship. Interpreting the analysis in terms of labour supply and demand, we view this long-run relationship as a regional labour market equilibrium. Therefore, our analysis sheds light on the extent to which population and employment adjust to equilibrate local labour markets.

Because we analyse regional time series, region and time-specific effects can be included in the model. The resulting two-way error components model (Baltagi, 2001) controls for time-invariant unobserved heterogeneity, such as regional amenities or comparative advantages, that affects local population and employment growth, and it also controls for national trends. Omitted variables have been recognized to obscure identification of the interaction (Boarnet, 1994a, p. 150), so this method improves reliability of the estimates substantially. In one of the few studies using time-series, Steinnes (1977) has called for the use of panel data techniques to better identify the mutual dependency of population and employment. To our knowledge, we are the first to do so in an urban economic context.

The model is estimated on regional population and employment growth in The Netherlands, using annual data between 1973 and 2000. On the spatial level of aggregation observed, about thirty percent of the working labour force on average has a job outside the residential region[2]. These regions should thus be considered open labour markets. Our analysis is neither intra- nor intermetropolitan. Instead, the geographical structure of The Netherlands, consisting of many relatively small cities, may be described as a set of overlapping urban areas[3]. Interestingly, these data include internal migration and natural population increase, which allows us to model the adjustment process more accurately.

The remainder of the paper is structured in the following way. The next section derives a general simultaneous error correction model for regional population and employment growth that accounts for commuting, and interprets it in terms of regional labour market dynamics. In section 3, we show how this model can be applied dealing with issues such as internal migration, changes in the housing stock, labour force characteristics and the role of regional industry mix. Estimation issues and empirical results are discussed in section 4. The final section concludes and provides some more discussion.

2. Modelling regional labour market dynamics

Mutual dependency of regional population and employment necessitates analysis in a simultaneous equations model. Because adoption of these variables to exogenous shocks can take considerable time, it would be natural to include lags in such a model. In addition, a host of other factors affect regional population, employment or both. A general model for regional population and employment could thus take the following form:

$$\begin{aligned} POP_{i,t} &= f\left(A_1(L)POP_{i,t}, A_2(L)\overline{EMP}_{i,t}, X_{i,t}, u_{i,t}\right), \\ EMP_{i,t} &= g\left(A_3(L)EMP_{i,t}, A_4(L)\overline{POP}_{i,t}, Y_{i,t}, v_{i,t}\right), \end{aligned} \tag{2.1}$$

[2] The regional unit (the so-called COROP area) is substantially larger than the municipalities used in the Boarnet (1994a, b) papers for example, but smaller than US counties and certainly states.
[3] It has been argued by Van Ommeren et al. (2000) that in overlapping urban areas which include open labour markets, the distinction between intra- and interregional mobility seems less meaningful. This implies that the response of regional population growth to housing markets should be taken into account as well.

where $POP_{i,t}$ and $EMP_{i,t}$ denote the level of population and employment in region *i* and year *t*. The lag polynomials $A_k(L)$ account for the dynamic adjustment process, so for example $(\alpha_0 + \alpha_1 L)POP_{i,t} = \alpha_0 POP_{i,t} + \alpha_1 POP_{i,t-1}$. Exogenous variables are summarized by $X_{i,t}$, $Y_{i,t}$, and $u_{i,t}$, $v_{i,t}$ are independently distributed disturbances. The functions *f* and *g* can take arbitrary form.

We interpret population as potential labour supply, and employment as labour demand. The system of equations (2.1) can thus be viewed as a regional labour market model, describing local adjustment of demand and supply. However, when regional labour markets are open, as is the case for regions in an intrametropolitan analysis for example, such a model should account for commuting. People and firms in one region may supply and demand labour in another, which implies that regional demand and potential supply of labour depend on the spatial distribution of employment and population.

Interregional commuting is incorporated in the model by means of spatial weight matrices W^1 and W^2, which are applied to regional employment and population in the first and second equation of system (2.1) respectively. We compute $\overline{EMP}_{i,t} = \sum_j w_{ij}^1 EMP_{j,t}$, where w_{ij}^1 is the probability that someone working in region *j* lives in region *i*[4]. Multiplying this probability by employment in region *j* we get the expected number of people working in *j* that live in region *i*, and summing over employment regions yields the expected working labour force in region *i*. We interpret this variable as the *expected labour demand*, conditional on the spatial distribution of employment.

Similarly, we compute $\overline{POP}_{i,t} = \sum_j w_{ij}^2 POP_{j,t}$, where w_{ij}^2 is the probability that someone living in region *j* would work in region *i*. Multiplying this probability by population in region *j* we get the *expected* number of people living in region *j* that potentially work in region *i* (the probability is also applied to people that do not participate). The sum over population regions is interpreted as the *expected (potential)*

[4] These probabilities are derived from an estimated model for interregional commuting. They are based on distance between regions only. See the appendix for details.

labour supply, conditional on the spatial distribution of population (potential labour force).

We formulate the model (2.1) as a linear relationship[5]. For ease of exposition, only one time lag will be included, but this can be straightforwardly extended to an arbitrary number. The following specification is obtained:

$$POP_{i,t} = \alpha_1 POP_{i,t-1} + \alpha_2 \overline{EMP}_{i,t} + \alpha_3 \overline{EMP}_{i,t-1} + \mu X_{i,t} + u_{i,t},$$

$$EMP_{i,t} = \beta_1 EMP_{i,t-1} + \beta_2 \overline{POP}_{i,t} + \beta_3 \overline{POP}_{i,t-1} + \nu Y_{i,t} + v_{i,t}, \quad (2.2)$$

where for meaningful interpretation, it is required that $\alpha_1 \leq 1$ and $\beta_1 \leq 1$[6].

There are a number of advantages to rewriting this system in first differences. Since the time series used can be expected to portray some autocorrelation, this procedure will reduce multicolinearity of the endogenous variables and their time lags. A second point is that the resulting model can be interpreted as an error correction model. Responses of the change in population and employment to exogenous shocks can thus be decomposed into an instantaneous reaction and an adjustment towards long run equilibrium.

We write system (2.2) as a simultaneous error correction model by substituting $POP_{i,t} = \Delta POP_{i,t} + POP_{i,t-1}$ and $EMP_{i,t} = \Delta EMP_{i,t} + EMP_{i,t-1}$, and rearranging terms[7,8]:

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[5] In the empirical application, a log linear specification will be used.

[6] It can not be precluded that regional population and employment time series are nonstationary. It has been argued by some, that regional population and employment are co-integrated time series (eg. Freeman, 2001). In this case, the variables should also be first differenced, and the system (2.3) can be estimated using the two-step method proposed by Engle and Granger (1987).

[7] This derivation can be found in every textbook on econometric analysis of time series.

[8] The other explanatory variables can be rewritten in the same way, which may be desirable if they are expected to affect long run relationships.

$$\Delta POP_{i,t} = \alpha_2 \Delta \overline{EMP}_{i,t} - (1-\alpha_1)\left(POP_{i,t-1} - \frac{\alpha_2 + \alpha_3}{1-\alpha_1} \overline{EMP}_{i,t-1} \right) + \mu X_{i,t} + u_{i,t} \,,$$

$$\Delta EMP_{i,t} = \beta_2 \Delta \overline{POP}_{i,t} - (1-\beta_1)\left(EMP_{i,t-1} - \frac{\beta_2 + \beta_3}{1-\beta_1} \overline{POP}_{i,t-1} \right) + \nu Y_{i,t} + v_{i,t} \,. \tag{2.3}$$

Regional labour demand and supply can be considered to be in equilibrium when $POP_{i,t} - ((\alpha_2 + \alpha_3)/(1-\alpha_1))\overline{EMP}_{i,t} = 0$ and $EMP_{i,t} - ((\beta_2 + \beta_3)/(1-\beta_1))\overline{POP}_{i,t} = 0$. Deviations from these long run relationships are corrected by changes of population and employment, provided that $\alpha_1, \beta_1 < 1$, which explains the name *error correction model*. In other words, regional labour markets can be considered to be in equilibrium when the ratio of potential labour supply and expected labour demand in the first equation, and the ratio of employment and expected labour supply in the second equation, attain their long run values. When the population in a region is large with respect to expected labour demand, population growth here will be small ceteris paribus. Reversely, when employment in a region is large with respect to expected labour supply, employment growth here will be small ceteris paribus. In this way, regional population and employment can be seen to adjust towards equilibrium.

The notion underlying the ratio's of labour demand and supply is *participation*. We say that a regional labour market is in equilibrium if an equilibrium share of the population participates (supplies labour)[9]. When population in a region is large with respect to expected labour demand, given the spatial distribution of employment, participation here is low compared to its equilibrium value. This implies that competition for jobs on the regional labour market is high, so that it is more difficult for people to obtain a job. In turn, this can be expected to depress net incoming migration and thus population growth. When employment in a region is large with respect to expected labour supply, given the spatial distribution of population, participation here is high with respect to its equilibrium. Competition for workers is thus high and it is more difficult for firms to hire someone in this region. This can be expected to depress employment growth.

[9] Note that participation is defined here as the share of the potential labour force that has a job, so the unemployed do not participate in our definition.

Thus we have derived a regional labour market model, where regional growth of population and employment responds to developments in expected labour demand and supply, and to deviations labour market equilibria. Although the model may seem to differ strongly from the one proposed by Boarnet (1994a, b) and others following him, we show in the appendix that imposing a parameter restriction leads to a specification that has exactly the same dynamic properties as his model. This implies that we can test down from a general model to the lagged adjustment dynamics that is assumed in this literature. However, our general model identifies both short and long run effects, and therefore provides more information on the underlying labour market adjustment processes. Another difference with these studies is the way in which we account for commuting. Instead of using a rather mechanical spatial weight matrix, we interpret this matrix in terms of expected regional labour demand and supply. As shown in the appendix, this leads to a different specification. In the next section, we will apply this model to regional labour markets in The Netherlands and derive an estimable specification.

3. Application to population and employment growth in The Netherlands

The geographical structure of the area analysed has a defining importance for the way regional population and employment interact. As we have argued in the introduction to this paper, it would be inappropriate to view the Netherlands either as a metropolitan area or as containing various metropoles. In reality, the country contains numerous relatively small cities that are not strictly separated by rural areas, yielding overlapping urban areas. Labour markets overlap as well. For example, it takes only about one hour by train to travel between Amsterdam and Rotterdam, the two largest cities in the Netherlands. Moreover, a large number of cities and residential areas lie between them. Commuting between these cities is substantial, so that their labour markets are far from closed. Because the regions we analyse are not much larger than cities[10], they should be considered overlapping urban and labour market areas as well. On this scale residential

[10] These regions are called COROP areas, and they coincide with European NUTS III level. Most regions contain one larger city.

migration[11] plays an essential role in population development, since these moves are not intra-regional in general[12].

The geographical structure of the Netherlands thus differs significantly from US metropolitan areas. Another striking difference between these two countries is the institutional setting. Regulation of labour and housing markets in the Netherlands is much stronger than in the US. Most wages are bargained at the national level by labour unions (this holds for about 80 percent of all employees), employer organisations and the government. Firms cannot easily adjust their wages to regional labour market conditions, so wage differentials (corrected for personal characteristics and the sectoral composition of employment in a region) are likely to be small[13]. Housing markets in the Netherlands have been strongly regulated as well (Rietveld and Wagtendonk, 2003). Through zoning and other tools, both the national and local governments have been heavily involved in regional supply of houses[14]. Crucially, governments determine the location of new housing stock, and not so much the market.

Having sketched the geographical and institutional setting of our analysis, we now apply the regional labour market model derived in the previous section to the Dutch situation. We do so by introducing relevant explanatory variables first for population, and then for employment growth. Studies on migration in The Netherlands (Bartels and Liaw, 1987, Nijkamp and Rietveld, 1981) indicate that housing markets play an important role. Therefore, we include growth and lagged level of the housing stock in the population equation. As will become clearer in the next section, this latter variable may indicate equilibrium correction behaviour on regional housing markets.

The effect of regional labour markets on population growth is accounted for in model (2.3) by growth of the expected labour demand, conditional on the spatial distribution of

[11] As opposed to labour migration, that may be more important on US state level, for example.
[12] For example, the housing market in Amsterdam has been tight over the past decades. Many people have moved outside this city but on acceptable commuting distance. A number of new cities have emerged (Almere, Zoetermeer) that have very little employment in proportion to the number of residents, because most people commute to other regions. Population growth in these cities seems to have been determined by supply of houses and their distance to employment centres.
[13] In turn it has been shown using micro data that nominal wages are hardly a motive for labour migration (see Van Dijk et al., 1998).
[14] This is probably one of the causes for lagging supply in certain areas, so that regional housing price differentials have persisted. Housing markets in the west of the country, which is the most densely populated, have been tight throughout our period of observation.

employment, and deviation from a long-run relationship. We also include the ratio of regional added value to employment, which is a measure for labour productivity. Productivity should translate into wages in competitive labour markets, so that this variable may reflect the response of migration to regional wage differentials.

Because in the regional labour market model, population is interpreted as potential labour supply, we only consider population aged between 15 and 65. Dutch municipalities hold records of the local population, so we do not have to rely on censuses for measuring population growth. Instead, these records allow us to decompose annual population growth into natural population increase and net internal and foreign migration. Internal migration is the variable that reacts strongest to developments on regional labour and housing markets, and natural population increase should not respond at all. Therefore, our analysis becomes more accurate if we model net internal migration instead of regional population growth. A net migration model can be derived from (2.3) by moving natural population increase to the right hand side of the population equation[15]. The coefficient of this latter variable is not restricted because due to competition on housing and labour markets, a negative effect may be expected.

Mainly for reasons of robustness, we will estimate model (2.3) in log linear form. It is obtained by taking logs of all variables[16] except net migration and population increase, these variables should be divided by lagged potential labour force[17]. However, we present a linear form in this section for ease of exposition. Substituting the explanatory variables into the population growth equation of model (2.3) then yields the following model for net migration:

$$\begin{aligned} NIM_{i,t} = {} & A_i + B_t + \alpha_1 \Delta \overline{EMP}_{i,t} + \alpha_2 \overline{PRO}_{i,t-1} + \alpha_3 \Delta HOU_{i,t} + \alpha_4 NIP_{i,t} \\ & + \alpha_5 POP_{i,t-1} + \alpha_6 \overline{EMP}_{i,t-1} + \alpha_7 HOU_{i,t-1} + u_{i,t} \end{aligned}, \qquad (3.1)$$

where:

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[15] In this study we ignore net foreign migration.
[16] For the growth variables, logs should be taken before first differencing.
[17] The growth rate of population is approximately equal to the ratio of its first difference and lagged population. Now the first difference of population can be decomposed into net internal and foreign migration and natural population increase. We rewrite the model in such a way that the ratio of net migration and lagged population becomes the dependent variable, and the ratio of natural increase and lagged population is an explanatory variable.

$NIM_{i,t}$: net internal migration (incoming minus outgoing) of population aged between 15 and 65 (potential labour force);

$PRO_{i,t}$: productivity, regional added value divided by employment;

$HOU_{i,t}$: housing stock (number of dwellings);

$NIP_{i,t}$: natural increase of the population aged between 15 and 65;

$POP_{i,t}$: potential labour force, population aged between 15 and 65.

Note that the model (3.1) has been reparametrised for simplicity, long run relationships can be derived from there parameters in a straightforward way. Productivity, affecting labour demand, is multiplied by the same matrix W^1 as regional employment. Also, we have included region and time specific *fixed effects* A_i and B_t. Econometrically, the model is specified as a two-way error components model (Baltagi, 2001). We thus control for both regional heterogeneity (such as environmental amenities) and national trends, which strongly reduces the risk of omitted variables biases.

Similarly, we derive a model for regional employment growth in The Netherlands from the second equation in system (2.3). In this model, growth as well as the lagged level of expected labour supply, conditional on the spatial distribution of population, are included. We enter yet two more variables that affect labour supply through participation. The first one is the ratio of the number of children aged under 15 to the potential labour force. A high proportion of children can be expected to affect participation negatively, since they require care. A second variable is the proportion of the potential labour force aged under 35, which affects labour supply positively since participation decreases with age.

To the extent that regions produce for other regions or abroad (export), developments in (inter)national demand are expected to affect regional employment. If demand shifts upwards for an industry that is heavily represented in some region, employment here should increase. We operationalise this concept by introducing a (dynamic) *share* (Barff and Knight III, 1988) in the model. This is the regional employment growth that would be expected on the basis of national developments and the lagged industry composition of a region.

A second demand side factor is the regional productivity, as measured by the ratio of value added and employment. A larger regional productivity may be the result of *agglomeration economies*. Both pooled labour markets (through a more efficient matching process) and existence of knowledge spillovers would predict a higher per capita productivity (Fujita and Thisse, 2002). These economies of agglomeration may be expected to attract firms and employment.

Substituting these variables in the employment growth equation of model (2.3) yields the following specification (again we present the linear model, although a log linear specification will be estimated):

$$\begin{aligned}\Delta EMP_{i,t} &= A'_i + B'_t + \beta_1 \Delta \overline{POP}_{i,t} + \beta_2 \overline{CHI}_{i,t-1} + \beta_3 \Delta \overline{AGE}_{i,t-1} + \beta_4 SHA_{i,t} \\ &\quad + \beta_5 PRO_{i,t-1} + \beta_6 EMP_{i,t-1} + \beta_7 \overline{POP}_{i,t-1} + v_{i,t}\end{aligned}, \qquad (3.2)$$

where:

$CHI_{i,t}$: ratio of children aged under 15 to the potential labour force;

$AGE_{i,t}$: share of the potential labour force aged under 35;

$SHA_{i,t}$: share of industries.

This model has been reparametrised as well. The variables affecting labour supply are multiplied by the same matrix W^2 as regional population, since participation in one region may affect employment in another. Also in this equation we have included region and time specific fixed effects. Amongst other things, this controls for regional comparative advantages to the extent that they are time invariant.

In the specifications (3.1) and (3.2), the time dummies are dealt with by subtracting the national value for all variables, the national value for net internal migration is zero. The resulting simultaneous model explains the regional deviations of population and employment growth from national growth rates, to the extent that they vary over time.

4. Estimation

In formulating the simultaneous model (3.1) and (3.2) we have implicitly made a number of *exclusion restrictions*, some variables in our model enter only one equation. Such identifying restrictions are necessary in order to estimate the system consistently, since a variable that enters one equation can be used as an instrument for the endogenous variable in the other equation. The exclusion restrictions for equation (3.1) are that the ratio of children to the potential labour force, the share of the potential labour force aged under 35 and the share of industries do not directly affect net internal migration. The restrictions for equation (3.2) are that natural population increase and the lagged level of the housing stock do not directly affect employment growth[18].

Excluding demographic factors from the net migration equation may seem dubious. The ratio of children to potential labour force might positively affect net migration because households with children are generally less mobile, and the share of people under 35 might negatively affect net migration because young people are generally more mobile. We expect however that their effect on participation, and therefore employment growth, is much stronger than any possible effect on population growth. Validity of these restrictions will be tested using overidentifying restrictions.

Matters are slightly more complicated as exogeneity of growth of the housing stock cannot be assumed either. It may very well be that markets and the government respond to expected demand for housing, which is related to population growth and regional labour market conditions (Rietveld and Wagtendonk, 2003). However, because of overidentifying restrictions we can use the instruments for employment growth in the net migration equation to identify the effect of growth of the housing stock as well.

On identification we finally comment that expected labour demand and supply are computed using weight matrices derived from a commuting model (see section 2 and the appendix). In order to obtain consistent estimates, we apply the same weight matrices to the external instruments in the first stage regressions. This assumes that the

[18] An additional assumption we have to make is that lagged levels of population, employment and housing stock are exogenous. It is evident that these variables are predetermined. However, unbiased estimation of a fixed effects panel data model formally requires strict exogeneity. The assumption made in this paper is that the time series in our dataset are long, so that the estimators are consistent.

exclusion restrictions we make should also hold for spatially weighted instruments (cf. Boarnet 1994a, b).

The model presented in section 3 will be estimated on 1973 – 2000 Dutch regional time series. Employment (distinguishing a small number of industries) and regional productivity are based on regional accounts. One important comment on the data is that employment is measured in years and not in persons, and that we do not have information on the number of self-employed. However, our estimates are unaffected as long as the spatial distribution of the ratio of persons to years and the share of self-employed do not change over time, since this is controlled for by the region and time specific fixed effects. All demographic information stems from municipal administrations[19].

Tables (4.1) and (4.2) show estimation results for equations (3.1) and (3.2) respectively, for a number of specifications. We use the two stages least squares (TSLS) estimator, and weight by regional population and employment, averaged over time. Regional fixed effects are dealt with by subtracting the time average from all observations, and national trends are accounted for by subtracting the national value of all variables. The covariance matrix estimator is robust to regional heteroskedasticity and autocorrelation of arbitrary form within the regional time series[20].

In the first specification of the migration equation, growth of expected labour demand and growth of the housing stock are instrumented with the ratio of children to the potential labour force, the share of the potential labour force aged under 35 and the share of industries. In this specification, growth of the housing stock turns out to be the most important variable. A unit elasticity is not rejected, so that a one percent increase of the number of houses in a region leads to a population increase through net internal migration of about one percent. This finding may reflect the housing market tightness over our period of observation. Also the lagged level of the housing stock has a significantly positive effect, which indicates equilibrium correction behaviour on housing markets as we will see shortly.

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[19] Most data come from Statistics Netherlands, except information on the regional housing stock, which was provided by ABF Research.

[20] See Wooldridge (2002). Autocorrelation within the regional time series can be substantial, but we prefer a model where only short and long term effects are estimated to a full dynamic model.

Specification	I	II	III	IV
growth housing stock	0.832 * *0.181*	0.820 * *0.184*	0.772 * *0.202*	0.772 * *0.202*
growth labour demand	-0.047 * *0.099*	0.028 *0.013*	0.030 *0.013*	0.030 *0.013*
productivity	0.013 *0.007*	0.012 *0.006*	0.012 *0.006*	0.012 *0.006*
natural population increase	-0.087 *0.034*	-0.087 *0.034*	-0.086 *0.035*	-0.086 *0.035*
population level	-0.070 *0.012*	-0.072 *0.011*	-0.072 *0.012*	-0.033 *0.015*
labour demand level	-0.014 *0.013*	-0.007 *0.013*		
housing stock	0.046 *0.022*	0.045 *0.023*	0.039 *0.024*	
housing market equilibrium				-0.039 *0.024*
national trends	incor.	incor.	incor.	incor.
regional dummies	incor.	incor.	incor.	incor.
R-squared (demeaned)	0.319	0.323	0.327	0.327

*Table 4.1: net migration (equation 3.1), variables marked with a * are instrumented, regional fixed effects and national trends are incorporated by demeaning all variables, robust standard errors are italic style*

Both the lagged level and growth of expected regional labour demand, conditional on the spatial distribution of employment, are insignificant. This would imply that an increase of employment in a regional labour market affects net migration neither in the short nor in the long run. The only labour market related variable that appears significant is productivity, which may be interpreted as a measure for income. However, the effect is very small. If productivity in a region doubles with respect to national productivity, the population will increase by about one percent through net internal migration according to the model.

The effect of natural increase of the potential labour force is significantly negative. These young people compete for houses and jobs, which depresses incoming migration or leads to higher out migration. Given the dominance of the housing variables in the model, housing market tightness is likely to be the most important factor behind this finding.

The significantly negative effect of the lagged level of population has various interpretations. In the first place, because the area of a region is time invariant, and therefore taken account of in the fixed effects, this variable may be interpreted as population density. The result then indicates that people have moved to less densely populated areas, which is something we have actually observed over the past decades. Secondly, there may be a long run relation between population, generating housing demand, and housing supply. In combination with positive significance of the housing stock coefficient, the result may thus be partly interpreted as a response to deviations from regional housing market equilibria.

We have performed Hausman tests on the model, to test for exogeneity of the instrumented variables. At the 5-percent level, exogeneity of growth of the housing stock was rejected, but growth of expected labour demand not. Therefore, in a second specification only the former variable was instrumented. This yields a more precise estimate of the effect of growth of expected labour demand. Now we do find a significantly positive effect, but it is very small. If labour demand doubles in a region, then population will increase with three percent through net internal migration in this model. Other coefficients are similar to the first specification.

In the third specification, we have removed variables that were insignificant at the 5-percent level in the second specification, in this case only the lagged level of expected labour demand. This variable can be used as an additional instrument for growth of the housing stock. The coefficient of that variable is a bit lower, but does not differ significantly from the second specification. Significance of the lagged level of the housing stock now drops below the 5-percent level. Otherwise results remain similar.

Finally we try to disentangle the effect of the lagged level of population into a density effect and equilibrium correction on housing markets. This requires the assumption of a unit long run elasticity between population and housing stock. Regional population and housing stock are then assumed to be in equilibrium if the regional ratio of population and housing stock equals the national ratio up to a region-specific constant, or in the notation of the previous section: $POP_{i,t} / HOU_{i,t} = \varphi_i \, POP_{NA,t} / HOU_{NA,t}$. Estimation of a fourth specification that includes this equilibrium error term instead of the lagged housing stock, indicates that through net internal migration, regional differences in population density are decreased with three percent annually, and deviations from housing market equilibria are decreased with four percent annually.

In the first specification of the employment equation, growth of expected labour supply is instrumented with natural population increase and the lagged level of the housing stock. The effect of this variable is positive, but insignificant at the 5-percent level. However, the lagged level of expected labour supply has a significantly positive coefficient. This indicates equilibrium correction on regional labour markets through employment growth. We come back to this point when discussing the fourth specification.

Specification	I	II	III	IV
growth labour supply	0.036 * *0.029*	0.052 *0.039*		
ratio of children	-0.075 *0.029*	-0.075 *0.029*	-0.076 *0.028*	-0.076 *0.028*
share of people under 35	0.086 *0.041*	0.085 *0.042*	0.089 *0.040*	0.089 *0.040*
share of industries	0.124 *0.341*	0.124 *0.341*		
productivity	0.028 *0.011*	0.028 *0.011*	0.028 *0.011*	0.028 *0.011*
employment level	-0.114 *0.018*	-0.114 *0.018*	-0.114 *0.019*	-0.053 *0.017*
labour supply level	0.062 *0.025*	0.063 *0.024*	0.061 *0.026*	
labour market equilibrium				-0.061 *0.027*
national trends	incor.	incor.	incor.	incor.
regional dummies	incor.	incor.	incor.	incor.
R-squared (demeaned)	0.095	0.095	0.094	0.094

*Table 4.2: employment growth (equation 3.2), variables marked with a * are instrumented, regional fixed effects and national trends are incorporated by demeaning all variables, robust standard errors are italic style*

The variables that affect labour supply through participation, the ratio of children and the share of the potential labour force aged under 35, both have significant coefficients at the 5-percent level. It appears that employment growth is smaller in regions where households have more children on average, and it is larger in regions where the potential labour force is relatively young. Of the demand side factors, the share of industries coefficient is insignificant even at the 10-percent level. However, there is a small but significant effect of productivity. Regions where labour is relatively productive apparently attract firms. This indicates existence of agglomeration effects. Note however, that the effect is small.

The lagged level of employment significantly affects employment growth. Again, there are various interpretations possible. In the first place, relatively land extensive industries may have moved away towards areas where there is less production. Secondly, in combination with the positive significant coefficient for the lagged level of labour supply, this may indicate equilibrium correction behaviour on regional labour markets. We try to disentangle these effects in the fourth specification.

Exogeneity of expected labour supply growth was tested for by means of a Hausman test. Exogeneity was not rejected, and therefore the second specification was estimated using OLS instead of TSLS. The coefficient of the variable is slightly larger, but remains insignificant even at the 10-percent level. Other coefficients seem unaffected.

Variables with insignificant coefficients at 5-percent level, in this case the share of industries and growth of expected labour supply, were dropped in specification three. Other coefficients appear unaffected. Finally we split the effect of the lagged level of employment into a density effect and equilibrium correction on labour markets. This interpretation assumes a long-run elasticity between employment and labour supply of unity. Regional employment and expected labour supply are thus in equilibrium when the regional ratio of employment and labour supply equals the national ratio up to a region-specific constant, or $EMP_{i,t} / \overline{POP}_{i,t} = \psi_i \, EMP_{NA,t} / \overline{POP}_{NA,t}$. Estimation of this fourth specification indicates that through employment growth, regional differences in employment density are decreased with five percent annually, and deviations from labour market equilibria are decreased with six percent annually.

The specifications for employment growth all explain about ten percent of the variance, after controlling for national trends and regional fixed effects[21]. This is substantially less then the share of the variance that is explained by the migration equation specifications,

[21] The R-squared statistic is computed as the square of the correlation between observed and projected employment and migration. Note that instrumented variables are used for this projection, and not the actual values.

which is roughly a third. One explanation may be that national trends are more important determinants of regional employment growth than of regional population growth. Another would be that growth of the regional housing stock largely determines net migration, and that we do not observe such a dominant variable for regional employment growth.

We test validity of the instruments used by means of an overidentifying restrictions test. In the first specification of the net migration equation there is only one overidentifying restriction. The test does not reject the instruments used, but it is rather week because the share of industries turns out to be a weak instrument. In the third specification there are two more overidentifying restrictions, because growth of expected labour demand is assumed exogenous and its lagged level is used as an instrument. Still, the instruments are not rejected. In the employment equation we have one overidentifying restriction, which does not reject the instruments used. This indicates that our model is properly identified[22].

In the appendix we show that lagged adjustment dynamics, such as used in numerous studies on the interaction of population and employment, can be tested as two joint cross-equation restrictions on the model proposed here. We have tested the lagged adjustment hypothesis for the second and third specification of the simultaneous model. For the second specification, lagged adjustment dynamics is rejected at the 10-percent level of significance, and for the third specification it is rejected at the 5-percent level. This indicates that for our data, assuming lagged adjustment dynamics is inappropriate. In addition, our findings illustrate that additional insight into adjustment processes can be gained from identifying both short and long-run effects, a distinction that is ignored when assuming lagged adjustment dynamics.

5. Conclusions

We have studied the interaction of regional population and employment through labour markets. A simultaneous error correction model has been derived that distinguishes

[22] Note that Boarnet (1994a, b) rejects validity of his exclusion restrictions by means of a similar test. He speculates that this is due to omitted land use variables. Using regional fixed effects, the risk of omitted variables is strongly reduced in our model, so that we can properly identify the simultaneity of population-employment interaction.

short term effects and a response to disequilibrium. Accounting for commuting between regions, this model incorporates labour demand and supply, expected on the basis of the spatial distribution of employment and population respectively. It has been shown that our model generalizes the lagged adjustment specification, such as used in Carlino and Mills (1987), Boarnet (1994a, b) and much of the literature following these papers. Moreover, this dynamic specification was tested and rejected for our data.

The model derived has been estimated on Dutch regional time series. These regions are larger than the municipalities studied in Boarnet (1994a, b), but interregional commuting cannot be ignored. This is partly due to the geographical structure of The Netherlands, the regions in our analysis should be considered as overlapping urban areas and overlapping labour markets. The data include internal migration and natural population increase, allowing us to model the adjacent process more accurately. Finally, the time series structure of our data enables to correct for unobserved regional heterogeneity and national developments by means of fixed effects. This largely improves on reliability of the estimates, and enables proper identification of the simultaneity in population-employment interaction.

We find a small effect of growth of labour demand on population growth through internal migration. However, the latter variable is unaffected by disequilibrium on regional labour markets. This finding is consistent with for example Van Dijk et al. (1989) and Broersma and Van Dijk (2002), who argue that internal migration does not serve to equilibrate regional labour markets in The Netherlands. However, we do find an indication that regional wages affect migration. Growth of the housing stock is by far the most important determinant. This was expected since housing markets have been tight throughout the past decades, especially in the west of the country.

Consistent with the Boarnet (1994b) hypothesis that employment is not exogenous to local population growth, we do find a significant effect of labour supply in the employment equation. However, this interaction is not through an immediate effect, but employment growth responds to deviation from regional labour market equilibria. We conclude that equilibrium on regional labour markets is established through changes in employment, rather than migration. This illustrates the insights in terms of underlying adjustment mechanisms that can be obtained by distinguishing short and long-run effects, something which ignored in a lagged adjustment model. Other supply side factors, such as the age composition of the potential labour force and the average number of children play a significant role as well. Demand side factors such as the share and productivity are clearly less important, though we do find an indication of agglomeration economies.

The overall picture is that housing markets largely determine regional population development, and supply side factors dominate the spatial distribution of employment. This evidence is in line with the Borts and Stein (1964) hypothesis, see also Muth (1991). In contrast, it casts doubt on appropriateness of regional export base and multiplier models, which heavily rely on the assumption that local factor supply constraints are absent.

Appendix 1: a test for lagged adjustment dynamics

We show that lagged adjustment dynamics, such as used in numerous papers on regional population and employment interaction, are equivalent to a restricted specification of the model derived in section 2. The Boarnet (1994a, b) model is used as example because our model resembles it also in other perspectives.

Point of departure in this model is an equilibrium relation between regional population, employment and regional characteristics:

$$POP^*_{i,t} = \gamma \overline{EMP^*}_{i,t} + \mu' X_{i,t} + u_{i,t} ,$$

$$EMP^*_{i,t} = \delta \overline{POP^*}_{i,t} + \nu' Y_{i,t} + v_{i,t} . \tag{A.1}$$

Furthermore, it is assumed that regional population and employment adjust towards these equilibrium values in the following way:

$$\Delta POP_{i,t} = \lambda_{POP}\left(POP*_{i,t} - POP_{i,t-1}\right),$$

$$\Delta EMP_{i,t} = \lambda_{EMP}\left(EMP*_{i,t} - EMP_{i,t-1}\right). \tag{A.2}$$

It is assumed that the same adjustment dynamics apply to potential variables. From these equations, an estimable model is derived:

$$\Delta POP_{i,t} = \lambda_{POP}\left(\gamma\overline{EMP}_{i,t-1} + \frac{\gamma}{\lambda_{EMP}}\Delta\overline{EMP}_{i,t} + \mu' X_{i,t} - POP_{i,t-1}\right) + u'_{i,t},$$

$$\Delta EMP_{i,t} = \lambda_{EMP}\left(\delta\overline{POP}_{i,t-1} + \frac{\delta}{\lambda_{POP}}\Delta\overline{POP}_{i,t} + \nu' Y_{i,t} - EMP_{i,t-1}\right) + \nu'_{i,t}. \tag{A.3}$$

Now this model can be rewritten as a simultaneous error correction model:

$$\Delta POP_{i,t} = \gamma\frac{\lambda_{POP}}{\lambda_{EMP}}\Delta\overline{EMP}_{i,t} - \lambda_{POP}\left(POP_{i,t-1} - \gamma\overline{EMP}_{i,t-1}\right) + \lambda_{POP}\mu' X_{i,t} + u'_{i,t},$$

$$\Delta EMP_{i,t} = \delta\frac{\lambda_{EMP}}{\lambda_{POP}}\Delta\overline{POP}_{i,t} - \lambda_{EMP}\left(EMP_{i,t-1} - \delta\overline{POP}_{i,t-1}\right) + \lambda_{EMP}\nu' Y_{i,t} + \nu'_{i,t}. \tag{A.4}$$

The simultaneous model (A.4) bears strong resemblance to the one that was derived in section 2. In fact, the following reparametrisation has to be applied to model (2.3) to obtain it:

$$\alpha_1 = 1 - \lambda_{POP} \qquad \beta_1 = 1 - \lambda_{EMP}$$

$$\alpha_2 = \gamma\lambda_{POP} / \lambda_{EMP} \qquad \beta_2 = \delta\lambda_{EMP} / \lambda_{POP}$$

$$\alpha_3 = \gamma(\lambda_{EMP} - 1)\lambda_{POP} / \lambda_{EMP} \qquad \beta_3 = \delta(\lambda_{POP} - 1)\lambda_{EMP} / \lambda_{POP}$$

$$\mu = \lambda_{POP}\mu' \qquad \nu = \lambda_{EMP}\nu'$$

From this reparametrisation we can derive two restrictions, which are $\alpha_3 + \beta_1\alpha_2 = 0$ and $\beta_3 + \alpha_1\beta_2 = 0$. Crucially, these restrictions imply that short and long-run effects are not separately identified in the lagged adjustment model. This shows that our model generalises lagged adjustment dynamics, which can be tested as two joint cross-equation parameter restrictions.

Appendix 2: accounting for interregional commuting

In the simultaneous model for population and employment growth (2.3), expected labour demand and supply in a region are computed as $\overline{EMP}_{i,t} = \sum_j w_{ij}^1 EMP_{j,t}$ and $\overline{POP}_{i,t} = \sum_j w_{ij}^2 POP_{j,t}$. In these equations, w_{ij}^1 is the probability that someone working in region *j* lives in region *i*, and w_{ij}^2 is the probability that someone living in region *j* would work in region *i*. These probabilities are derived from an estimated commuting model, and they are based on distance between regions.

Interregional commuting is modelled by means of a doubly constrained spatial interaction model that takes the following form:

$$COM_{ij,t} = WLF_{i,t} EMP_{j,t} A_{i,t} B_{j,t} F(d_{ij}) \ . \qquad \text{(A.5)}$$

In this model, the number of commuters $COM_{ij,t}$ increases proportionally with the potential labour force $WLF_{i,t}$ in the region of residence and employment in the region of work, but decreases with a distance decay function $F(d_{ij})$. The balancing factors $A_{i,t}$ and $B_{j,t}$ account for two sets of identities, which are that outgoing flows sum to regional working labour force, and incoming flows sum to regional employment. In this way, the model accounts for unobserved heterogeneity on the regional level and it is identified on flows.

We split the distance decay function into three components:

$$F(d_{ij}) = \exp(\alpha_i D_i^1 + \beta_i D_i^2 + \gamma_i d_{ij}). \qquad \text{(A.6)}$$

It is assumed that the number of commuters between two regions decreases exponentially with distance. The first dummy D_i^1 corrects for commuting within regions and the second D_i^2 measures border effects. We allow all variables to have a region specific effect, in order to deal with regional heterogeneity[23].

The parameters α_i, β_i and γ_i have been estimated on 1992 – 2000 commuting data from the Dutch Labour Force Survey. Distance between two regions is measured by the average number of car kilometres travelled by commuters. See Vermeulen (2003) for details.

In order to avoid endogeneity in model (2.3), the probabilities w_{ij}^1 and w_{ij}^2 are based on the distance between regions only. Using the estimated distance decay function, they take the following form:

$$w_{ij}^1 = \frac{F(d_{ij})}{\sum_i F(d_{ij})}, \qquad w_{ij}^2 = \frac{F(d_{ji})}{\sum_i F(d_{ji})}. \tag{A.7}$$

Note that these weights sum to one, which makes them suitable for an interpretation as probabilities. The resulting matrices W^1 and W^2 differ from the spatial weight matrices that are common in spatial econometric applications in two perspectives. In the first place, numbers on the diagonal are smaller than one, because diagonal flows have been included in the commuting model. Compare Boarnet (1994a, b), who puts zero's on the diagonal of the spatial weight matrix, and adds an identity matrix. Secondly, computing the required probabilities amounts to column normalization, instead of the usual procedure of row normalization. Both deviations stem from our interpretation of spatially lagged employment and population as expected labour demand and supply, conditional on the spatial distribution of these variables.

[23] Alternatively, we have imposed that seventy percent of the working labour force works in the residential region. Estimation results in section 4 where robust to this change.

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