A COINTEGRATION MODEL FOR SEARCH EQUILIBRIUM WAGE FORMATION

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In flow models of the labor market, wages are determined by negotiations between workers and employers on the surplus value of a realized match. From this perspective, this paper presents an econometric analysis of the influence of labor market flows on wage formation as an alternative to the traditional specification of wage equations in which unemployment represents Phillips-curve or wage-curve effects. The paper estimates a dynamic wage equation for the Netherlands using a cointegration approach. It finds that labor flows, and notably flows from outside the labor market, are important determinants of both short-run and long-run wage setting.

I. Introduction

Modern empirical studies of the labor market pay ample attention to labor market dynamics. Besides job destruction, job creation, and job-to-job mobility,

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wage formation forms a cornerstone of these studies (Blanchard and Diamond 1992 and Mortensen and Pissarides 1994). The theoretical basis is the equilibrium search model, in which wage formation is described as a Nash bargaining problem of sharing the local monopoly rent of a successful match between an employer and an employee (see for example Pissarides 1996). In this paper we apply this theory to derive an empirical wage equation. Specifically, we specify a wage equation for the Netherlands that is derived from a Nash bargaining process in a flow model with three labor market states: employed, unemployed, and outside the labor market. The outcome of the bargaining process yields a specification of the wage equation with various flows between these labor market states as determinants.

Our specification of the wage equation extends the traditional specifications of the wage equation, which includes some measure of unemployment as a determinant of wages. Nowadays Phillips's (1958) empirical relationship between the rate of change of wages and unemployment has a number of alternative theoretical foundations. Phelps (1968) has shown how the Phillips-curve effect can be derived from the behavior of the firm. In a newer tradition, trade union behavior has been shown to imply a relationship between the level of wages and unemployment: the so-called wage-curve (Oswald 1982, Blanchflower and Oswald 1990, and Graafland 1992). However, neither of these theoretical derivations of the wage equation prescribes that the unemployment rate or some transformation thereof should act as a measure for labor market tightness. Instead, the theory allows for a much wider set of indicators. In this respect, Blanchard and Katz (1997) point at the importance of labor market flows for wage setting, although their empirical estimates consider only the relationship between unemployment and wages. Broersma and Den Butter (2001, 2002) estimate specifications of wage equations where various labor-flow variables that represent labor market tightness are included on an ad hoc basis. This paper builds on these previous studies. From a formal theoretical model, we derive a specification of a flow-based wage equation, which is estimated using the cointegration approach. In our estimates, we use aggregate time-series data on these labor flows for the Netherlands, constructed according to a recently developed national accounting method (Broersma, Den Butter, and Kock 2000, and Kock 2002).

In the next section, the theoretical specification of the flow-based wage equation is presented. It is also shown how our specification relates to traditional empirical studies of the labor market. Section III describes the flow data that we use and presents our cointegration estimates of the wage equation. Section IV concludes.

II. Wages as a shared surplus of matches in the labor market

In recent years much research has been done on the empirical application of equilibrium search models. Van den Berg and Ridder (1998) have used panel data to estimate a structural equilibrium search model. Others have calibrated an equilibrium search model to explain unemployment dynamics, such as Ljungqvist and Sargent (1998). This paper focuses on a particular aspect of empirical search models, namely wage formation. Equilibrium search theory, which is the theoretical background of empirical search models of the labor market, provides an adequate framework for the inclusion of labor market flows as determinants in the wage equation. Like many previous papers, this paper will follow Diamond (1982), Mortensen (1982) and Pissarides (2000) and derive a wage equation from the assumption that the surplus of a match is shared between the worker and the employer according to a Nash bargaining game. Millard's (1997) unemployment equilibrium model, for example, also follows this tradition and assumes that the bargaining is carried out in such a way to ensure efficient job destruction, i.e., jobs are only destroyed when it is in the interest of both the worker and the employer (see also Millard and Mortensen 1997). A recent extension of this model by Brigden and Thomas (2003) considers wage formation and the effects of different shocks on the economy in the United Kingdom, while distinguishing between the search intensities of non participants and unemployed job seekers.

Search behavior is also the focus of an interesting study by Yashiv (2000). This study focuses on the process of matching vacancies and unemployed job searchers, and on the underlying search behavior of employers and workers. Based on the optimizing behavior of employers and workers, Yashiv estimates the Euler equation for both groups, derives steady state unemployment, and is able to empirically assess its main determinants. While Yashiv uses a simultaneous estimation approach with equations for workers and employers, to focus his analysis on unemployment and labor market flows, we use a single equation approach to assess wage formation.[1]

Instead our analysis is much inspired by Gautier's (1997) empirical model of labor market dynamics which uses the Nash bargaining solution to derive a wage equation in which outflow rates from employment and unemployment and outflow rates of vacancies determine wages. In doing so we follow the Diamond-Mortensen-

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[1] The data set used in the Yashiv paper is unique, as it contains information on both wages and search intensity. Our data, described in the Appendix, lack that information.

Pissarides approach and derive a basic equation for wage formation where wages are determined as a shared surplus of matches of employers seeking for workers and workers searching for jobs. In equilibrium, the inflow into employment and unemployment equals the outflow. We start by writing down asset values for each of the worker and job states. For simplicity it is assumed that job destruction is an exogenous process. To avoid clutter we omit the time index *t* in this presentation, but note that the denominator of the flow rates should be lagged one period.

A. Basic search equilibrium wage equation

The asset value of being employed is equal to the wage minus the probability of becoming unemployed (the lay-off rate) times the associated wealth loss of becoming unemployed, plus the expected change in the job value or:

$$iW_E = w - \frac{F_{EU}}{E}\left[W_E - W_U\right] + \overset{\bullet}{W}_E, \tag{1}$$

where *i* represents the discount rate, *w* is the real wage rate, W_E is the asset value of being employed, W_U is the asset value of being unemployed, F_{EU} is the flow of workers from employment to unemployment and *E* is the employment stock. The dot indicates the expected change in the asset value, which is zero in equilibrium. Similarly, the asset value of being unemployed is given by

$$iW_U = b + \frac{F_{UE}}{U}\left[W_E - W_U\right] + \overset{\bullet}{W}_U, \tag{2}$$

where *b* is a flat rate unemployment benefit, and *U* is the unemployment stock. We ignore other (expected) real returns that the worker might enjoy while unemployed (cf. Pissarides 2000, p. 13). Along the same lines we can define the asset value of a filled job, W_F. It is equal to the real value added (*y*) per worker minus wage costs (*w*) minus the lay-off rate (F_{EU}/E) times the associated wealth change when the job is abandoned,

$$iW_F = y - w - \frac{F_{EU}}{E}\left[W_F - W_V\right] + \overset{\bullet}{W}_F. \tag{3}$$

Finally, the asset value of an unfilled vacancy (W_V) is equal to the probability that it will be filled times the associated change in wealth minus the costs of forgone output and the costs of posting the vacancy, such as advertisement costs,

$$iW_V = \frac{F_{UE}^v}{V}\left[W_F - W_V\right] - yc + \dot{W}_V .$$ (4)

F_{UE}^v is the rate at which vacancies are filled up and it is defined by an aggregate matching function. We assume that the hiring costs (c) are proportional to the real value added per worker, which equals the value of the vacancy if a worker were to fill it.

The surplus of a match is shared between the worker and the employer according to a Nash bargaining game. As in the traditional wage curve models it is assumed that a generalized Nash bargaining solution formalizes the outcome of the bargaining process between a representative employee (or union) and a representative employer (or employers' organization),

$$\max_{w_i} \Omega(w_i) = \left[W_E - W_U\right]^{\beta}\left[W_F - W_V\right]^{1-\beta} .$$ (5)

This is similar to the bargaining solution of a traditional wage curve model, where the worker's and employer's threat points represent their utility during a breakdown in the bargaining process. In the bargaining solution (5) of the equilibrium search model the threat points W_U for workers and W_V for employers represent the present value of (expected) income streams of an unemployed worker and the present value of the expected profit from a vacant job, respectively. β is a parameter representing the relative bargaining strength of the worker, or the union.[2] It can be shown from the first- and second-order conditions of (5) that any exogenous variable that increases the threat point present value of the worker's income stream or decreases the threat point present value of the employer's income stream, raises the wage outcome of the bargaining process. Hence, a higher replacement rate increases the wage bargaining outcome.

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[2] It is usually assumed that β equals 0.5 but there may be circumstances that justify a different β, for example when employers and unions have different rates of impatience (Pissarides 2000).

The first order maximization conditions for both the worker and employer surplus imply $(1-\beta)[W_E - W_U] = \beta[W_F - W_V]$. We can now derive the wage equation by imposing the condition that in equilibrium all profit opportunities from new jobs are exhausted and hence the value of a newly opened vacancy is zero, $W_V = 0$.[3] Note that in equilibrium the expected change in the value of a particular state (unemployed or employed) or job (filled or vacant) is also zero. Following Pissarides we can derive an expression of the wage by imposing the equilibrium condition and substituting W_E and W_F from (1) and (3) into the bargaining solution (5), to arrive at $w = iW_U + \beta(y - iW_U)$. We substitute (4), the Nash bargaining solution and the equilibrium condition for vacant jobs, $W_V = 0$, into (2) to arrive at

$$iW_U = b + \frac{F_{UE}}{U}\left(\frac{\beta}{1-\beta}\left(\frac{yc}{F_{UE}^v/V}\right)\right),$$

which we substitute into the previous expression for w to find a convenient expression for the equilibrium wage rate,[4]

$$w = (1-\beta)b + \beta y\left(1 + c\,\frac{F_{UE}}{U}\,\frac{V}{F_{UE}^v}\right). \tag{6}$$

If we assume that all workers find a job by filling a vacancy, so $F_{UE} = F_{UE}^v$, then we can rewrite (6) as $w = (1-\beta)b + \beta y(1 + c\theta)$. This is the basic aggregate equilibrium wage equation in Pissarides' equilibrium search model with θ representing a measure of labor market tightness U/V.

B. Adding taxes, wage related benefits, and non-participants

The wage equation (6) can be refined by including proportional income taxes t for workers and replacing the flat rate unemployment benefits b by wage related benefits (represented by the replacement rate rr times the wage rate). Similar to our derivation of wage equation (6) we can now derive

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[3] This condition results from the implicit assumption that firms can enter the market without any restrictions.

[4] This equilibrium condition implies that $W_F = yc/(F_{UE}^v/V)$. This also follows directly from (4) when $W_V = 0$ and $\dot{W}_V = 0$.

$$w = \frac{1-\beta}{1-rr(1-\beta)}(1-t) + \frac{\beta}{1-rr(1-\beta)}\left(1 + c\,\frac{F_{UE}}{U}\,\frac{V}{F_{UE}^{v}}\right)y, \tag{7}$$

From equation (6) we can see that the equilibrium wage is increasing in y, c and the flat rate benefit b. Increases in c (the cost of posting a vacancy) and b strengthen the bargaining position of the workers and as a result the wage will rise. Workers are likely to bargain over real after-tax wages instead of the nominal wage bill, so taxes increase wage demands by the worker. Therefore direct taxes and social premiums paid by workers influence the bargaining outcome. Equation (7) shows that the equilibrium wage is decreasing in t and increasing in the replacement rate rr.

In the exposition above we assume that workers can be either employed or unemployed. In the real world, however, there is a third state, namely workers outside the labor force. Gautier (1997) derives an equation for wage formation where wages are determined as a shared surplus of matches in the labor market, where matches can originate from unemployment as well as from outside the labor force (non-participants). In equilibrium, inflow and outflow in each of the three states has to be equal.

Unlike in the model of Brigden and Thomas (2003) it is assumed that persons outside the labor force have no direct influence on wage formation, so the wage equation is derived by specifying asset equations for unemployed and employed workers and for filled and vacant jobs. Non-participants enter the wage formation process through the inclusion of the quit rate from employment to outside the labor force (F_{EN}/E) in the asset equation for filled jobs and to include F_{NE}^{v}/V (the flow rate from out of the labor force to employment) in the asset equation for vacant jobs. The asset equations (3) and (4) for filled and vacant jobs can be modified to

$$iW_F = y - w - t - \frac{F_{EN} + F_{EU}}{E}\left[W_F - W_V\right] + \overset{\bullet}{W}_F, \text{ and} \tag{8}$$

$$iW_V = \frac{F_{UE}^{v} + F_{NE}^{v}}{V}\left[W_F - W_V\right] - yc + \overset{\bullet}{W}_V. \tag{9}$$

Based on these asset equations, Gautier (1997) then derives the following, slightly modified, wage equation:[5]

$$w = \frac{\beta(y + yc - t)\left[i + \dfrac{F_{EU}}{E} + \dfrac{F_{UE}}{U}\right] + (1 - \beta)b\left[i + \dfrac{F_{UE}^v + F_{NE}^v}{V} + \dfrac{F_{EU} + F_{EN}}{E}\right]}{i + (1 - \beta)\left[\dfrac{F_{EU} + F_{EN}}{E} + \dfrac{F_{UE}^v + F_{NE}^v}{V}\right] + \beta\left[\dfrac{F_{EU}}{E} + \dfrac{F_{UE}}{U}\right]}. (10)$$

Although the theoretical foundation of this flow-based wage curve differs from a traditional wage curve model like, for instance, Oswald (1982), a common feature is that a bargaining process determines the wage level. The main theoretical difference is in the way unemployment influences the bargaining outcome. In traditional wage curve models rising unemployment reduces the union's bargaining power, and hence the wage level, because utility is lower for an unemployed worker than for an employed worker. In search models of the labor market with equilibrium unemployment the causality runs via the employer's bargaining power. Rising unemployment reduces the employer's search costs because of shorter vacancy duration and therefore lowers labor turnover costs, which improves the employer's threat point in the wage bargaining process. The theoretical wage models presented here indicate that there are ample grounds for an explorative econometric analysis of the influence of labor market flows on wage formation.

C. Stylized facts of wage formation in the Netherlands

There appears to be some convergence of evidence in empirical models of wage formation in the Netherlands (see for example Van de Wijngaert 1994 for a survey). Increases in consumers plus producers prices are fully passed on to wages as the elasticity of prices to wages is estimated (or set) equal to unity. In most models the same applies to labor productivity; in many models there is a unit, or at least near-unit elasticity between productivity and wages. In other words the wage space is fully used for wage increases. The wage space is defined as the sum of price inflation and labor productivity and has played an important role as a benchmark in wage negotiations in the Netherlands. A recent example of an empirical study on wage formation in the Netherlands using the wage bargaining model is

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[5] The wage equation can be derived in a number of ways (Pissarides 2000, p. 16-17). Gautier chooses to derive the flow version (10), while we choose to derive the aggregate wage equations (6) and (7) that hold in equilibrium. Note that the discount rate i drops out in equilibrium.

the wage equation included in the JADE-model of the CPB Netherlands Bureau for Economic Policy Analysis (Central Planning Bureau (CPB) 2003). This equation is traditional in the sense that unemployment plays (amongst others) a role as determinant for wage formation in a wage curve specification. The equation encompasses empirical knowledge on wage formation in the Netherlands. Its focus is on the tax wedge, and more specifically on the possibilities for employers and workers to pass on increases in direct taxes and social security contributions to customers (through higher prices) and employers (through higher wages) respectively. Like in our empirical model of the next section, the wage equation in JADE is specified as a cointegration and error correction model. It allows for an asymmetric influence of the wedge on the short run, whereas the influence of the wedge on long run wage formation is symmetric although its incidence does not completely fall on workers.

III. Empirical implementation

The flow variables used in our estimates are defined as rates, where a flow from x to y is indicated as $fxy=F_{XY}/X_{t-1}$. We use the following variables: $feu=F_{EU}/E_{t-1}$ (flow from employment to unemployment, or the lay-off rate) and $fue=F_{UE}/U_{t-1}$ (the flow from unemployment to employment, or the hiring rate). The flow from employment to out of the labor force (the quit rate) is defined as $fen=F_{EN}/E_{t-1}$. It consists of workers who quit their job due to regular and early retirement and workers who leave the labor force due to disability. The other two flow variables in equation (10) relate to persons filling a vacancy: $fuev = F_{UE}^{v} / U_{t-1}$ is an unemployed worker filling a vacancy and $fnev = F_{NE}^{v} / N_{t-1}$ is somebody outside the labor force filling a vacancy. The flow data that we use for estimation are constructed using a national accounting method, discussed in the Appendix. The accounting method and the selection of data sources enables us to include labor market flows from outside the labor force into employment and unemployment and it ensures that individuals are not double counted. We choose to use annual flow data, because the set of quarterly data (see Kock 2002 for a discussion) is only available for a relatively short sample period, while the annual data cover the period 1970-1997. The Appendix provides more information on the data and its construction method.

A. Cointegration equation

We log-linearized equation (10) using a first order Taylor approximation. Given

the limited number of observations available we use the basic cointegration approach and the two-step procedure of Engle and Granger (1987) to specify our empirical model. First the static long-term equilibrium wage level relation is estimated. In the second step we estimate the associated dynamic error correction specification. Unit root test results (which are available upon request) indicate that all variables are I (1) in the observation period.

Table 1. Estimation results of cointegration equation for 1970-1997 sample period

$\log w = 0.68 \log y - 0.77 \log (1-t) + 1.08 \log rr - 1.28\,feu - 5.74\,fen - 0.004\,(fuev + fnev) - 7.28$
(0.027)   (0.238)   (0.094)   (0.484)   (1.566)   (0.001)   (0.546)

Adjusted R^2 = 0.99; ADF = 4.44; PP = 3.83; DW = 1.53; N=26

Notes: ADF is Augmented Dickey-Fuller test statistic on stability of the residuals of the regression. PP is Phillips-Perron test statistic on stability of the residuals. Critical value at 5 percent significance level is 3.59. DW is the Durbin Watson test statistic. Standard errors are in parentheses. N is the number of observations. Estimation method: OLS

The estimation results of a static long-term equilibrium wage level relation based on a linearized version of equation (10) are reported in Table 1. The outflow out of unemployment turned out not to be significant and was dropped from the final estimation. A test could not reject equality of the coefficients of the two variables that represent vacancy outflow due to employment inflow from unemployment and due to employment inflow from out of the labor force, and hence these two variables were combined into a single indicator of labor market tension.

The replacement rate, productivity and tax variables all show the correct sign. Higher benefits increase the bargaining power of workers, thereby raising the real wage rate. In fact, the estimated coefficient of 1.08 for the replacement rate suggests full adjustment of wages to changes in the benefit level in the long run: when benefits rise with 1 percentage point over wages in the end this leads to an equal rise in the wage level. Other studies find less then full adjustment; with coefficient values between 0.17 and 0.33 (see Van de Wijngaert 1994, and the previous discussion on the JADE-model). Still, we feel that our specification of a long-run relationship suggests that a constant replacement rate is plausible. It is also consistent with the long-standing Dutch policy of annually adjusting benefits in line with the average nominal wage increase in the private sector in the past year.

The long run adjustment coefficient for productivity of 0.68 is broadly in line with the results of other studies, which find coefficients between 0.71 and 1.09. Apparently workers are able to translate more than two-thirds of the productivity increases into higher wages, leaving employers and other capital providers with the remainder. Our estimates seem consistent with the notion that tax cuts support wage moderation (the estimated coefficient for the tax rate of –0.77 is within the range of most other studies). Proponents claim that a policy of tax cuts contributed significantly to employment growth in the Netherlands in the 1980s and 1990s, often suggesting that the tax cuts were part of a coordinated policy effort by the government, unions and employers that enabled unions to moderate wage demands. However, our results also allow for an alternative interpretation, which suggests that tax cuts stimulated labor supply, which led to lower wage pressure.

Note that our specification of our wage equation is neither a wage curve, nor a Phillips curve. A wage curve explains the wage level by the level of unemployment, or similarly, wage growth is explained by the change in unemployment. A Phillips curve, on the other hand, explains wage growth by the level of unemployment. Both the wage curve and the Phillips curve can be seen as the outcome of a wage negotiation process between employers and employees (Blanchflower and Oswald 1990, and Knoester and Van der Windt 1987). Although we also derive our wages from such a negotiation process, we find instead that the wage level is explained by labor market flows. In fact these flows are employment inflow from unemployment and non-participation and employment outflow to unemployment and non-participation.[6] The underlying implication is that it is labor market flows instead of

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[6] Economic theory is ambiguous as to what the sign of the coefficients of the flows into employment by filling a vacancy (*fuev* and *fnev*) should be. Let's assume for a moment that U/V is the proper measure of labor market tightness. In the steady state the relation between labor market tightness and wages is obvious: any increase in unemployment or decline in vacancies pushes down wages. From a flow perspective, however, things are not so obvious. When non-participants fill vacancies, the U/V ratio increases (vacancies decline but U remains unchanged) and hence we would expect downward wage pressure, although this is somewhat counter intuitive. When U/V changes because unemployed workers fill vacancies, both the nominator and the denominator change and the overall effect depends the relative size of U and V. U/V, however, might not be the proper measure of labor market tightness. A better measure would be, for example, $(U + \alpha N)/V$, where α is a coefficient (between zero and 1) that indicates the degree to which non-participants participate in the labor market. Alternatively α can be seen as a coefficient of job search intensity. In that case the change in labor market tightness due to inflow from unemployed workers and non-participants that fill vacancies depends on the initial number of vacancies and job seekers, as well as the relative weight (or search intensity) of non-participants (the magnitude of α).

the change or the level of the unemployment rate that determine the bargaining power of employers and employees. So, our flow-based wage curve is linked to the traditional wage- and Phillips-curve theories since in all three bargaining between workers and employers determines the wage outcome. Another link appears when we focus on the flows into and out of unemployment. With a similar but opposite effect of these flows on the wage level, the wage level in our model would depend on the change in unemployment, or, in terms of growth, wage growth would be explained by the acceleration or deceleration of unemployment growth. It implies that the specification of our model of wage formation differs from both the wage curve specification and from the Phillips curve specification.

Our empirical estimates are based on a reduced form single-equation where wages are determined by the outcome of a Nash bargaining game with respect to the surplus of the match between workers and employers. In this respect the theoretical underpinning of our model differs from system-equation methods such as the model of Millard (1997) and the previously discussed dynamic model by Yashiv (2000). These models derive theoretical relationships for job destruction and job creation, and simultaneously estimate wages and labor market flows.

Although theoretically sound, our single-equation approach could potentially suffer from identification problems. From previous simultaneous equation analysis for the Netherlands we have learned, however, that simultaneity is unlikely to be a serious problem. In Broersma and Den Butter (2001) a simple model of the wage-price spiral is estimated, consisting of equations for wages, prices and labor market flows. In Broersma and Den Butter (2002) the Johansen simultaneous cointegration approach is applied to derive three different cointegration relations. One of these cointegration equations resembles a wage equation and the other two model a combination of unemployment inflow and outflow. Because these simultaneous equation estimates did not differ much from single-equation estimates in these studies we are confident that simultaneity does not distort the estimates in the present study.[7]

Does the estimated cointegration equation make sense from an economic perspective? We think it does. For instance, in case of a recession we observe an increase in the inflow into unemployment, which in our model reduces the bargaining

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[7] We also note that in other studies of Philips-curves and wage equations, such as Philips (1958) and Blanchflower and Oswald (1990), identification and simultaneity were not considered major problems. Furthermore, the limited number of observations in our dataset, when used to estimate a simultaneous equation system of wages and labor market flows would lead to questionable results.

power of workers and therefore causes moderate wage growth. In other words, changes in labor market flows govern wage growth rates instead of changes in (or levels of) labor market stocks. This paper provides both a theoretical and empirical underpinning of this insight.

B. Dynamic wage equation

Our theoretical model derived in Section 2 considers a steady state solution of search equilibrium in the labor market. However in reality there are adjustment lags. Therefore, in our empirical analysis we allow for these adjustment lags and use the cointegration approach to estimate the dynamic wage equation in error correction form (Table 2). We prefer to specify the non-flow indicators in logs to establish a relation between the percentage change in the real wage rate and the percentage change in productivity, taxes and the replacement rate (cf. Graafland 1990a and 1990b). The indicators of labor market tension are specified as first differences of flow rates. Our specification approach is to move from a general to a specific model. The general model specification includes contemporaneous and lagged dynamic variables and the error correction term from the model in Table 1.

Table 2. Estimation results of dynamic wage equation for 1970-1997 sample period

$$\Delta \log w = .95\Delta \log y - .73\Delta \log(1-t) + .73\Delta \log rr - 1.48\Delta\ feu_{-1} - 4.01\Delta\ fen_{-1} - .003\Delta\ (fuev_{-1} + fnev_{-1}) - .65\ err_{-1} - .006$$

| (0.141) | (0.241) | (0.100) | (0.538) | (1.260) | (0.001) | (0.189) | (0.003) |

Adjusted R^2 = 0.83; SSR = 0.001; SE = 0.008; DW = 2.13; N=25

Notes: SSR is the sum of squared residuals and SE is the standard error of regression. DW is the Durbin Watson test statistic. *err* is the derived residual from the cointegration equation. Standard errors are in parentheses. N is the number of observations. Estimation method: OLS.

Our estimation results suggest an almost instant adjustment of wages to changes in productivity, possibly because workers are successfully forward looking with respect to productivity changes and take this into account when negotiating nominal wages. Policy changes might be more difficult to predict, which would explain why wage adjustments in response to changes in the tax rate and the replacement rate take somewhat longer, although with a coefficient of 0.73 the short run adjustment elasticities are still quite high.

The lay-off rate (*feu*) and the flow of workers who leave the labor force (*fen*) push the wage rate down. The results that we find for the lay-off rate are comparable with other studies for the Netherlands, with long run coefficients between –1.20 and –2.01 (see Van de Wijngaert 1994). The negative impact of *fen* on wages is notable. From a theoretical point of view, the impact of labor market outflow on wages can be positive or negative, depending on whether the stochastic or endogenous component in this flow dominates. On the one hand, the stochastic component relates to workers who leave employment due to regular retirement or disability. This outflow from employment reduces labor supply and hence wages increase. On the other hand, the endogenous component relates to workers who leave the labor force by choice-either their own or their employer's-mainly because weak economic conditions encourage them to retire early, rather than face the prospect of unemployment. These separations from employment are associated with declining wages.[8] This type of outflow to non-participation reduces workers' bargaining power and hence wages decline for the same reason that lay-offs cause lower wages.

The results suggest that in our sample the flow from employment to non-participation is dominated by the choice component. In fact, the wage impact of the flow out of the labor force is bigger than the impact of the lay-off rate. The former flow has rarely been used in an empirical study, as far as we know.[9] A plausible explanation would be that the average wage rate is lower for workers that are being laid-off than for workers leaving the labor force for early-retirement or other non-participation because workers in the later group are most likely older and are more unionized. Another way to see this is to consider the impact of different outflow rates for these two groups over the business cycle. In a boom the lay-off rate will decrease more than the separation rate to non-participation, because

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[8] Frijters and Van der Klaauw (2003) estimate an empirical job search model with a similar mechanism. In their microeconomic model unemployed job seekers leave the labor force (a flow from unemployment to non-participation) when their reservation wage falls below their utility from non-participation. This mechanism illustrates that the large negative coefficient that we find for flows from employment to outside the labor force *(fen)* could in part involve reverse causality. On the other hand, to the extent that non-participants are part of effective labor supply, an increase in *fen* could very well push down wages (see also footnote 6).

[9] An exception is the study of Brigden and Thomas (2003). However, in their model it is impossible to write down a single reduced form equation linking movements in the stock of unemployed workers or non-participants to wage pressure. That is because the relationship between job seekers and wage pressure depends on the source of the shock that caused the unemployment rate or the inactivity rate to move.

most people will make their retirement decision independent of the business cycle. Faced with a smaller stock of unemployed workers to hire from, employers are then forced to hire more expensive non-participants, pushing up the wage rate even further. In a recession the more or less constant outflow of relatively expensive workers to non-participation reinforces the downward wage pressure, which is a result of lay-offs.

The impact of the flow of filled vacancies turns out surprisingly small. The error correction term in the dynamic wage equation is significant and indicates that current wages are corrected for past errors. The coefficient of 0.65 indicates that short run (partial) adjustment is quite fast, although in the JADE model a coefficient value of 0.85 was found which suggest that wages approach their long run levels even more quickly.

IV. Conclusion

This paper empirically investigates the influence of labor market dynamics on wage formation. The traditional literature models wage formation either as a Phillips curve (where the unemployment rate is a determinant of the change in the wage rate) or a wage curve (where the unemployment rate is a determinant of the wage level). Our specification of the wage curve implies a third possible long-term relationship between wages and economic variables: the wage level is a function of labor market flows and other explanatory variables. In fact, we use the change in the unemployment rate as an explanatory variable in the wage curve, since flows in and out of unemployment determine the change in the level of unemployment in each period.

We find that labor market flows are suitable substitutes for traditional indicators of labor market tightness and hence qualify for inclusion into the wage equation. More specifically, we find that a combination of the outflow from employment to unemployment (layoffs), the outflow from employment to non-participation, and the outflow of vacancies (successful matches) determine the wage level. This corresponds with the theoretical foundation of the wage equation, which describes wage formation as the outcome of a bargaining game between employers and employees, in which the relative bargaining power depends on labor market tightness. Our results support the notion that, especially in the context of equilibrium search theory, labor market flows are relevant for the outcome of the wage-bargaining process.

Appendix: Data sources and definitions

The non-flow data were obtained from the national accounts of Statistics Netherlands (CBS) and the CPB Netherlands Bureau for Economic Policy Analysis (CPB). We use annual data and the sample period is 1970 – 97: w is real wage rate of workers in enterprises (source: CPB); y is value added per worker, market sector only (source: CPB); rr is replacement rate, weighted average of welfare and unemployment insurance benefits (source: CPB); t is direct taxes on wage income (transaction based) (source: CPB).

The flow data used in this paper were constructed using a national accounting system for labor market flows, which is discussed in detail in Broersma, Den Butter, and Kock (2000) and Kock (2002). Those papers also provide a sensitivity analysis of the construction method and compare the results with other studies and data sources. Below is a summary of the national accounting system, which is constructed in three steps.

Step 1: Primary sources. We identify and collect data on the stocks and flows that are available from primary sources. The entire national accounting system generates 27 labor market flows (eighteen worker flows and nine job flows) and 6 stocks: Employed (E), Unemployed (U), workers outside the labor force or Non-participants (N) and Vacancies (V). Non-participation includes everyone above age 14 who is not part of the labor force and is defined as the sum of disabled workers (N_D) and a residual category labeled other non-participants (N_O), which includes retired workers and students, among others. Unemployed workers receive unemployment insurance benefits (U_I) or welfare (U_W). We disregard part-time employment because our accounting system does not allow individuals to be included in more than one group at a time. The flows of workers are indicated by the general symbol F_{xy}^z, which denotes the flow from x to y, $(x, y) = \{U_W, U_I, E, N_D, N_O\}$, with, when relevant, $z = j$ in case of newly created jobs, $z = v$ in case of jobs for which a vacancy existed, and z is omitted if no job flow is involved.

All stocks of persons and vacancies and nine flows (the total inflow of new vacancies and eight worker flows) are available from primary sources, albeit that we sometimes have to combine different sources. It appears that flow data are available for employment outflow (to unemployment insurance, occupational disability and other non-participation) and for the flow out of unemployment insurance provisions (to employment and non-participation).

Step 2: Assumptions. The second step is to make additional assumptions to

close the accounting system. It turned out that we have to make twelve assumptions, of which some are related. All parameters in the assumptions are based on micro-economic evidence and panel data surveys that are discussed in Kock (2002). We apply the following fixed assumptions for worker flows:

$$F_{N_D N_O} = N_{D(65+)} + 0.55 * N_{D(\text{recovery})} \tag{A1}$$

$$F_{N_D U_W} = 0.20 * N_{D(\text{recovery})} \tag{A2}$$

$$F_{N_O U_W} = 0.50 * N_{O(\text{schoolout})} \tag{A3}$$

$$F_{U_W N_O} = 0.4 * U_W O \tag{A4}$$

The first assumption specifies that the share of workers receiving disability benefits who leave the labor market depends on the number of benefit recipients that reach the retirement age of 65 and the number of benefit recipients that recover from disability. According to the second assumption a proportion of disabled workers that recover qualify for unemployment benefits. Assumptions A3 and A4 specify the flows between welfare recipients and non-participation. The inflow into welfare depends on the number of graduating students, while the reverse flow is assumed to be a share of total outflow from welfare.

As regards job flows, we distinguish between job searchers filling a vacancy (e.g. F_{UE}^{v}) and job searchers who take up a job for which no vacancy existed (e.g. F_{UE}^{j}). As there is no information on the relative importance of the two types of flows into employment, we have to make assumptions on one of them. We assume that the inflow into employment without filling a vacancy is a fraction of the total flow into employment. This fraction ξ is the share of total hires which do not lead to an outflow of vacancies in a particular year, $\xi = \left(H - VO_f\right)/H$, where H is the number of hires and VO_f is the number of filled vacancies. We get $F_{EE}^{j} = \xi F_{EE}$, $F_{UE}^{j} = \xi F_{UE}$, and $F_{NE}^{j} = \xi F_{NE}$. In order to determine the fraction ξ we need information on the number of filled vacancies, which together with the number of scrapped vacancies determines the total outflow of vacancies. We assume that the number of scrapped vacancies is a function of the stock of vacancies; $VO_s = 0.30 * V$. Note that unlike the worker flow assumptions, the parameters in the job flow assumptions are not fixed. Instead ξ depends on specific labor market conditions.

Step 3: Equations. We use the stock and flow information gathered in the previous steps to derive the resulting flows by means of definition equations and stock-flow equations. Definition equations refer to job and worker flows that are linked, such as employment inflow by means of filling a vacancy and vacancy outflow. Stock-flow equations are used to derive the remaining flows, based on a simple accounting rule that indicates that the change in a stock equals inflow minus outflow, all measured over the unit period of observation.

Using assumptions A1 and A2 we can derive the flow of occupational disabled who find a job as follows: $F_{N_D E} = F_{N_O N_D} + F_{EN_D} - \Delta N_D - F_{N_D N_O} - F_{N_D U_W}$. Using assumptions A2, A3, and A4 we can derive the inflow into employment from welfare, $F_{U_W E} = U_W O - F_{U_W N_O}$. Finally, we derive the inflow into the labor force of non-participants who find a job from $F_{N_O E} = EI - F_{U_W E} - F_{U_I E} - F_{N_D E}$, where EI is the total inflow into employment, defined as $EI = EO + \Delta E = F_{EU_I} + F_{EN_D} + F_{EN_O} + F_{EM} + \Delta E$, with F_{EM} representing worker mortality.

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