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Abstract

This paper studies the relationship between the change in the unemployment rate and output growth using an approach based on labour market flows. The framework shows why the Okun coefficient may be constant/time-varying and/or symmetric/asymmetric and that the outcome lies with the behaviour of the labour flows in response to growth. The encompassing framework nests the conditions to determine the properties of the Okun coefficient without the need to rely on retrospective arbitrary dating of recessions. The framework also highlights the potential mispecification in conventional models of Okun's Law unless stringent conditions are assumed about the behavior of labour flows. The empirical analysis is based on the stock-consistent labour market flows data developed by the BLS for the period 1990:2-2017:3.

JEL classification: E24, E32, J21

Keywords: Labour flows, time-varying Okun, asymmetry

1 Introduction

There is a large body of research based on Okun (1962) with researchers (like Okun himself) approaching the relationship in different ways. The most common approaches are the 'difference approach' (i.e. examining the relationship between the change in the unemployment rate and output growth) and the 'gap approach' (i.e. examining the relationship between the deviation of the actual from the natural or equilibrium unemployment rate, on the one hand, and the gap between the level of actual and potential output, on the other). The policy questions of interest include: Is there a relationship between the two and how large is the Okun coefficient? Does the Okun coefficient vary depending upon whether the economy is contracting or booming? Has the relationship changed over time, once we allow for possible asymmetry?

Recently, in an important paper, Ball et al. (2017) investigated the Okun relationship for the US and 20 other advanced economies. Focusing on the fit of the relationship between the unemployment rate and output (using both the gap and difference form of Okun's Law) they find for US data over the sample period 1948-2013 that Okun's law is a strong, reliable and stable relationship and that a constant (not time-varying) Okun coefficient is a good approximation to reality.[1] They also noted that the Okun coefficient appears to be larger during recessions than during expansions.[2] How can we reconcile empirical evidence that Okun's coefficient is stable over time, while being asymmetric over the business cycle?

Our paper proposes another look at the relationship between changes in the unemployment rate and output growth through the lens of labor market flows. As far as we know, no one has utilized flows data in this context. Yet clearly the change in the unemployment rate reflects the balance of flows into and out of unemployment within a period and thus it is natural to look at the Okun relationship as a relationship between output growth and labor market flows.

[1] Knotek (2007) in his survey of the Okun relationship for the USA concluded that the Okun relationship has changed over time and is different during expansions and contractions while Owyang and Sekhposyan (2012) show that during recent U.S. recessions - including the Great Recession - unemployment appears to be more sensitive to economic growth than before. Cazes et al. (2013) also find that the Okun coefficient varies over time for the US (and other countries).

[2] Pereira (2013) concludes on the basis of an analysis of U.S. data that there are asymmetries in the Okun relationship with a weaker relationship during periods of expansion. Valadkhani and Smyth (2015) analyzing US data also find asymmetries and a weakening of the Okun relationship since the early 1980s. Furthermore, Belaire-Franch and Peiro (2015) examine U.S. (and the U.K.) data and conclude that there is an asymmetry in the relationship between unemployment and the business cycle.

Our analysis will focus on the 'difference approach' (not the 'gap approach') to Okun's Law since labor market flows are informative about the change in the unemployment rate. We also propose focusing on net flows (the balance of the gross flows between any two states) as they highlight more effectively the dynamics (including asymmetries) behind the evolution of the Okun coefficient.

The focus on labor flows also has two advantages. The first advantage is that our framework will be based on exact relationships between labor flows and the unemployment rate, participation rate and the employment-population ratio. We show how the flows framework provides an encompassing structure to study the relationship between GDP growth and changes in the unemployment rate and in particular, the conditions under which the Okun coefficient (i.e, the coefficient linking the change in the unemployment rate to the output growth rate) is time-varying and/or asymmetric. Specifically, the framework highlights the key role of the level of the lagged unemployment rate, irrespective of whatever dynamic structures are introduced. This then allows us to also show explicitly how the Okun coefficient is potentially time-varying and additionally, how it may display sign asymmetry (i.e., the change in the unemployment rate differs for positive/negative shocks to growth).

The second advantage of our focus on flows is that the data allows us to adopt a three-state analysis - namely flows between employment, unemployment and not in the labor force. As a result, our econometric SUR (seemingly unrelated regression) model of the relationship between labor market flows and output growth allows us to show how shocks to growth affects labor flows and how they, in turn, translate into changes in three summary statistics - the unemployment rate, the participation rate and the employment-population ratio. The method also explains how and why the evolution of the Okun coefficient may be constant or time-varying as well as symmetric or asymmetric. Importantly, the approach does not require the imposition of ex-post knowledge of recession periods.

The empirical analysis of the relationship between output growth, the flows, and the change in the unemployment rate is for the period 1990:2-2017:3. The start date is conditioned by the availability of the BLS's stock-consistent flows data.

In our model, time variation in the Okun coefficient depends on the effect of output growth on the net labor flows. To anticipate the empirical results, our analysis shows that, for this data set, the Okun coefficient is not time-varying because neither net flows from

unemployment to not in the labor force nor from employment to not in the labor force are sensitive to changes in growth. However, the Okun coefficient is asymmetric being larger in contractionary periods than expansionary periods because the net flows between employment and unemployment respond differently to positive and negative changes in growth.

Our contribution is threefold. First, we investigate the relationship between output growth and labor market flows in order to deepen our understanding of the relationship between output growth and changes in the unemployment rate. To be precise, our use of flows data allows us to explore issues such as: If there is asymmetry in the Okun relationship, what is the (proximate) source of the asymmetry, is it primarily due to the relationship between employment and unemployment flows, or flows into and out of the labor force (the discouraged worker effect) or both? In this particular context it is our hope that our empirical work would help direct theory work on the source of asymmetric behavior in labor markets.

Second, because we are able to incorporate into our model the impact of output growth changes on flows between *all* three labor market states (employment, unemployment and not in the labor force) we are able to examine in a consistent manner the implications of shocks to output growth not only on the unemployment rate (this is the Okun relation) but also on the labor force participation rate and the employment-population ratio. In that sense our approach is wider, more-encompassing, than the traditional approach.

Third, because it is the balance of flows into and out of each state which drives the relevant stocks up and down we show that a focus on the net flows between any two states is informative and succinct in econometric modeling and estimation as well as in interpreting the evolution of the summary labor market indicators - the unemployment and participation rates and the employment-population ratio. In that regard, our approach, while similar to time-varying parameter models (including regime-based analysis), is clearer about the driver of the time-variation, and also the sense in which the Okun coefficient is asymmetric, but the Okun relationship is stable over time.

The paper is organized as follows. Section 2 presents the flows framework linking growth, labor flows, and the unemployment and participation rates. We show how, from basic theoretical foundations, the Okun coefficient is likely to be time-varying, evolving asymmetrically between contractionary and expansionary periods.

Section 3 presents the empirical analysis. The SUR flows model is estimated and we

provide an assessment of whether the Okun coefficient for the US, is time-varying and/or asymmetric. The model is also simulated to illustrate how labor flows react to a positive and to a negative shock in the growth of real GDP and hence how the flows translate into changes in unemployment and participation rates as well as in the employment-population ratio. We also transformed the estimated flows over 1990:2-2017:3 to ascertain the evolution of the three labor market summary indicators over the sample period. We show that the model performs well in tracking actual changes and levels, including the fall in the participation rate in the past decade. Importantly, the focus on net flows highlights the likelihood of a discouraged worker effect, but working through an increase in the net flow from employment (not unemployment) to not in the labor force. Section 4 concludes.

2 Okun's Law: A Flows Approach

Labor flows have been used to study the labor market - and especially movements in the unemployment rate - since the seminal papers of Hans Singer (1939, a and b). In this section, we present the key equations linking the three summary statistics: the unemployment and participation rates, and the employment-population ratio - and the flows between employment, unemployment and out of the labor force. We then show how our flows framework can be applied to study the relationship between the change in the unemployment rate and output growth and importantly how the framework provides testable hypotheses about the evolution of the Okun coefficient.

2.1 Labor flows into employment, unemployment and out of the labor force

Let the three labor states S be employed, unemployed and out of the labor force (denoted as E, U and N respectively) and let the gross flows between the states over the quarter t be written as SS_t where $S = E, U, N$.[3]

The change in the unemployment rate (Δu_t) over any period is defined as:

$$\Delta u_t = \frac{U_t}{L_t} - \frac{U_{t-1}}{L_{t-1}} = \frac{\Delta U_t}{L_t} + \frac{U_{t-1}}{L_{t-1}} \left(\frac{L_{t-1} - L_t}{L_t} \right) \tag{1}$$

[3]This sub-section draws in part upon some ideas presented in section II of Dixon et al.(2015).

where U is the number unemployed and L is the size of the labor force. Δ is the first difference operator. Since the change in the number unemployed ΔU_t reflects the balance between the inflows into unemployment and the outflows from unemployment, we may write:

$$\Delta u_t = \frac{(EU_t - UE_t) + (NU_t - UN_t)}{L_t} - \left(\frac{\Delta L_t}{L_t}\right) u_{t-1} \tag{2}$$

where EU is the flow from employed to unemployed, UE is the flow from unemployed to employed, NU is the flow from not in the labor force to unemployed, and UN is the flow from unemployed to not in the labor force.

Similarly the proportional change in the labor force will reflect the balance between inflows into not in the labor force and the outflows from not in the labor force

$$\left(\frac{\Delta L_t}{L_t}\right) = \frac{(NE_t - EN_t) + (NU_t - UN_t)}{L_t} \tag{3}$$

Thus the change in the unemployment rate can now be written entirely in terms of the predetermined labor state variable (u_{t-1}) and the flows (expressed as a proportion of the labor force):

$$\Delta u_t = \frac{(EU_t - UE_t)}{L_t} + \frac{(NU_t - UN_t)}{L_t}(1 - u_{t-1}) - \frac{(NE_t - EN_t)}{L_t}(u_{t-1}) \tag{4}$$

The participation rate p_t is the ratio of the labor force to the population P_t:

$$p_t = \frac{L_t}{P_t} = \frac{E_t + U_t}{P_t} \tag{5}$$

Assuming for now, that population growth is zero, so that over any (short) period $P_{t-1} = P_t$ (see Appendix for case when $P_{t-1} \neq P$), we can write the change in the labor force participation rate as:

$$\Delta p_t = \frac{\Delta L_t}{P_t} = \frac{(NE_t - EN_t) + (NU_t - UN_t)}{P_t} \tag{6}$$

Further manipulation yields an expression for the rate of change in the participation rate as:

$$\frac{\Delta p_t}{p_t} = \frac{\Delta p_t}{L_t/P_t} = \frac{(NE_t - EN_t)}{L_t} + \frac{(NU_t - UN_t)}{L_t} \tag{7}$$

Note for future reference that we can compute the employment population ratio (e_t) as:

$$e_t = \frac{E_t}{P_t} = \frac{L_t - U_t}{L_t}\frac{L_t}{P_t}$$
$$= (1 - u_t)p_t \tag{8}$$

For notational convenience, define the following *net flows*

$$eu_t = \frac{(EU_t - UE_t)}{L_t} \tag{9}$$
$$en_t = \frac{(EN_t - NE_t)}{L_t} \tag{10}$$
$$nu_t = \frac{(NU_t - UN_t)}{L_t} \tag{11}$$

Note that "*net flow*" in this context is not the change in the number of people in any one labor state in any period, but rather the *balance* of flows between any two labor states which have taken place over the period. We focus on the *net flows* primarily because it is a very efficient way to see what is going on given that the gross flows are very highly correlated with each other. High positive correlations between the gross flows between any two states and especially between flows into and out of unemployment have been noted by Burda and Wyplosz (1994), Burgess and Turon (2005), Demiralp et al.(2011) and Elsby et al.(2013) amongst others. In our data set the (contemporaneous) correlation between EU and UE is 0.70, between NU and UN it is 0.95 and between EN and NE it is 0.87. Clearly it must be the *balance* of movements between states that are the key to understanding the effects of shocks on the unemployment rate as in the event of a shock the elements in each pair will tend to move in the same direction.

Using the definitions of net flows, given above, we can also write the change in the unemployment and participation rates succinctly as:

$$\Delta u_t = (eu_t + nu_t) + (en_t - nu_t)u_{t-1} \tag{12}$$
$$\Delta p_t = (nu_t - en_t)\, p_t \tag{13}$$

Equation (12) shows that Δu_t is affected directly by net flows to unemployment ($eu_t + nu_t$), and by the extent to which net flows change the labor force $u_{t-1}(en_t - nu_t)$.[4] Absent

[4]These equations also show that $\Delta p_t = 0$, when $nu_t = en_t$. In this case, Δu_t collapses to $eu_t + en_t$ and $\Delta u_t = 0$ when $en_t = -eu_t$. Thus, we note in passing that for labor market equilibrium ($\Delta p_t = \Delta u_t = 0$),

large changes in the level of activity these net flows are rather akin to a 'life-cycle' with the balance of flows being from not in the labor force to unemployment, from unemployment to employment and from employment to not in the labor force.

2.2 Econometric Model

The typical difference form of Okun's Law in its simplest form (leaving asymmetry aside for now) and allowing for lagged adjustment is:

$$\Delta u_t = \alpha + \beta_t \Delta y_t + \delta \Delta u_{t-1} + \varepsilon_t \tag{14}$$

where Δy_t is output growth and ε_t is the error term. This formulation generalizes the lag effects of Δy_t to allow for gradual decay (in other words, the lagged dependent variable term $\delta \Delta u_{t-1}$ is capturing the infinite lag effects of $\sum_{i=1} \gamma_i \Delta y_{t-i}$).[5] The Okun coefficient is β_t which is defined to allow for time variation.

Suppose we postulate that the flows are also similarly related to growth and the past change in the unemployment rate.[6] The lagged unemployment rate captures past changes in the state of the labor market

$$eu_t = \alpha_1 + \beta_{11} \Delta y_t + \delta_{11} \Delta u_{t-1} + \varepsilon_{1t} \tag{15}$$

$$nu_t = \alpha_2 + \beta_{21} \Delta y_t + \delta_{21} \Delta u_{t-1} + \varepsilon_{2t} \tag{16}$$

$$en_t = \alpha_3 + \beta_{31} \Delta y_t + \delta_{31} \Delta u_{t-1} + \varepsilon_{3t} \tag{17}$$

where $\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}$ are the error terms.[7] Then substituting the net flows equations (15)-(17) into the definitional equation (12) and re-arranging terms gives an expression (implied by

we require the absolute value of the three net flows to be equal: $nu_t = -eu_t = en_t$.

[5]Ball, et al. (2017) only allows for two lags: Δy_{t-1} and Δy_{t-2}. Using aggregate data on the change in the unemployment rate Δu and output growth Δy) we find, following the lag specification in Ball et al. (2017), an impact Okun effect of -0.153 and a long run effect of 0.455 (similar to results reported in that paper). When an aggregate model was estimated allowing for more general lag effects, we find that the fit is greatly improved (adjusted R^2 increased from 0.507 to 0.605) but the Okun coefficient remains similar being -0.167 on impact and -0.411 in the long run.

[6]We note that, we could have specified the system as a VARX and use lagged net flows. We have estimated this option, but the system with the lagged unemployment rate is parsimonious and performs better.

[7]In general, the approach discussed here can be generalized to a VAR set-up. Writing $\Delta u_t = G_{t-1} X_t$ where G_{t-1} is a (1x3) vector $[1, (1 - u_{t-1}), u_{t-1}]$ and X_t is a (3x1) vector of flows $[eu_t, nu_t, en_t]'$ then a VAR net flows model like $X_t = A + B\Delta y_t + DX_{t-1} + \epsilon_t$, where A, B, D are coefficient matrices, and ϵ is a vector of errors, will yield time-varying Okun coefficients $\beta_t = G_{t-1}B$.

the flows relationships) linking the change in the unemployment rate and output growth (inter alia) as:

$$\begin{aligned}\Delta u_t = &[(\alpha_1 + \alpha_2) + (\alpha_3 - \alpha_2)u_{t-1}] + [(\beta_{11} + \beta_{21}) + (\beta_{31} - \beta_{21})u_{t-1}]\,\Delta y_t \\ &+ [(\delta_{11} + \delta_{21}) + (\delta_{31} - \delta_{21})u_{t-1}]\Delta u_{t-1} \\ &+ [(\varepsilon_{1t} + \varepsilon_{2t}) + (\varepsilon_{3t} - \varepsilon_{2t})u_{t-1}] \qquad (18)\end{aligned}$$

With reference to equation (14) the time-varying Okun coefficient (β_t), the dynamic parameter δ_t and the intercept term (α_t),are respectively:

$$\beta_t = (\beta_{11} + \beta_{21}) + (\beta_{31} - \beta_{21})u_{t-1} \qquad (19)$$

$$\delta_t = (\delta_{11} + \delta_{21}) + (\delta_{31} - \delta_{21})u_{t-1} \qquad (20)$$

$$\alpha_t = (\alpha_1 + \alpha_2) + (\alpha_3 - \alpha_2)u_{t-1} \qquad (21)$$

The Okun coefficient is clearly time-varying (it depends on u_{t-1}), except when $\beta_{31} = \beta_{21} = 0$ or $(\beta_{31} - \beta_{21}) = 0$. The first term in equation (19) shows the direct effect of net flows to unemployment while the second term shows the effect of net flows on the labor force. In other words, Okun's coefficient will only be a constant ($\beta = (\beta_{11} + \beta_{21})$) when neither of the flows nu_t nor en_t are sensitive to changes in growth; or when they negate each other. The situation is also tantamount to assuming that the only flows which matter are those between employment and unemployment (i.e., only β_{11} in equation (15) matters). The constancy of the Okun coefficient is also dependent on β_{11} being significant and time-invariant. Note too that the specification here also illustrates how the coefficient will likely vary over the business cycle (because of the cyclical behavior of u_{t-1}) without the need to rely on retrospective time dummies to capture regimes.

Equation (18) also shows that Δu_t responds to the lag of *both* the level and the change in the unemployment rate. Importantly, we see that, independent of whatever dynamic structure is applied (in our case this is equivalent to ignoring the effect of Δu_{t-1}), we see that the effect of u_{t-1} appears in the "intercept". This means that the same output growth rate can result in a different Δu_t, depending on the value of u_{t-1}. In other words, unless the average values of the flows in and out of the labor force $(\alpha_3 - \alpha_2)$ are negligible (strictly speaking $(\alpha_3 - \alpha_2) = 0$ or $\alpha_3 = \alpha_2 = 0$), the dynamic adjustment of Δu_t will be time-varying. In addition, the significance of δ_{11}, δ_{21}, δ_{31} can be tested empirically for

richer dynamic behavior.

Equation (18) also shows why typical studies of Okun's Law based on equations like (14) are potentially mis-specified. Independent of the dynamic specifications and putting aside econometric complications associated with the composite error term, studies of Okun's Law without allowing a role for u_{t-1} (as a regressor) are implicitly making assumptions about the behavior of the net flows. One assumption could be that the average values of nu and en are zero ($\alpha_3 = \alpha_2 = 0$) and furthermore neither of these net flows are responsive to output growth ($\beta_{31} = \beta_{21} = 0$). The approach set out here allows researchers to test these assumptions since the econometric model estimated is based on the net flows specifications in equations (15)-(17).

Turning to the participation rate (under the assumption of no growth in population), and substituting the net flows equations (15)-(17) into the definitional equation (13) and re-arranging terms gives:

$$\frac{\Delta p_t}{p_t} = (\alpha_2 - \alpha_3) + (\beta_{21} - \beta_{31})\Delta y_t + (\delta_{21} - \delta_{31})\Delta u_{t-1} + (\varepsilon_{2t} - \varepsilon_{3t}) \tag{22}$$

Thus, the percentage change in the participation rate will not be affected by shocks to growth, only if $\beta_{31} = \beta_{21} = 0$ or $(\beta_{31} - \beta_{21}) = 0$; and, furthermore, it will be a constant when $\delta_{21} = \delta_{31} = 0$ or $\delta_{21} - \delta_{31} = 0$.

To recap: the flows framework provides deeper insights into the components of the difference specification of the Okun relationship and the circumstances when the Okun coefficient may be treated as constant over time (i.e., not time-varying). Our specification facilitates a number of testable hypotheses (including for the intercept and the autoregressive term).

2.2.1 Allowing for Asymmetry

Empirical analyses of Okun's Law generally find evidence of *sign* asymmetry, that is the change in the unemployment rate in response to negative growth is different from its response to positive growth. While the Okun coefficient in equation (19) is time-varying, it is symmetric because for a given level of u_{t-1}, the response of Δu_t to a positive or a negative Δy_t is the same. To allow for asymmetric effects we postulate that the flows are related to growth and the past change in the unemployment rate asymmetrically as

follows:[8]

$$eu_t = \alpha_1 + \beta_{11}\Delta y_t + \beta_{12}\left|\Delta y_t\right| + \delta_{11}\Delta u_{t-1} + \delta_{12}\left|\Delta u_{t-1}\right| + \varepsilon_{1t} \tag{23}$$

$$nu_t = \alpha_2 + \beta_{21}\Delta y_t + \beta_{22}\left|\Delta y_t\right| + \delta_{21}\Delta u_{t-1} + \delta_{22}\left|\Delta u_{t-1}\right| + \varepsilon_{2t} \tag{24}$$

$$en_t = \alpha_3 + \beta_{31}\Delta y_t + \beta_{32}\left|\Delta y_t\right| + \delta_{31}\Delta u_{t-1} + \delta_{32}\left|\Delta u_{t-1}\right| + \varepsilon_{3t} \tag{25}$$

The specification allows for sign asymmetry: in that when $\Delta y_t > 0$; the response of the net flow to a shock in growth is $\beta_{12} + \beta_{11}$; while for $\Delta y_t < 0$; the response of the flow to a shock in growth is $\beta_{12} - \beta_{11}$. Again, substituting and re-arranging terms:

$$\begin{aligned}
\Delta u_t = {} & (\alpha_1 + \alpha_2) + (\alpha_3 - \alpha_2)u_{t-1} \\
& + [(\beta_{11} + \beta_{21}) + (\beta_{31} - \beta_{21})u_{t-1}]\Delta y_t \\
& + [(\beta_{12} + \beta_{22}) + (\beta_{32} - \beta_{22})u_{t-1}]\left|\Delta y_t\right| \\
& + [(\delta_{11} + \delta_{21}) + (\delta_{31} - \delta_{21})u_{t-1}]\Delta u_{t-1} \\
& + [(\delta_{12} + \delta_{22}) + (\delta_{32} - \delta_{22})u_{t-1}]\left|\Delta u_{t-1}\right| \\
& + [(\varepsilon_{1t} + \varepsilon_{2t}) + (\varepsilon_{3t} - \varepsilon_{2t})u_{t-1}]
\end{aligned} \tag{26}$$

Thus the impact of a change in growth to the change in the unemployment rate (i.e., the Okun coefficient) is:

$$\begin{aligned}
\Delta y_t > 0 : \beta_t^+ &= [(\beta_{11} + \beta_{21}) + (\beta_{12} + \beta_{22})] + [(\beta_{31} - \beta_{21}) + (\beta_{32} - \beta_{22})](u_{t-1}) \\
\Delta y_t < 0 : \beta_t^- &= [-(\beta_{11} + \beta_{21}) + (\beta_{12} + \beta_{22})] + [-(\beta_{31} - \beta_{21}) + (\beta_{32} - \beta_{22})](u_{t-1})
\end{aligned} \tag{27}$$

in other words, the Okun coefficient is potentially time-varying and asymmetric.

We can also derive the relationship between the participation rate and output growth (again under the assumption of no growth in population) as:

$$\begin{aligned}
\frac{\Delta p_t}{p_t} = {} & (\alpha_2 - \alpha_3) + (\beta_{21} - \beta_{31})\Delta y_t + (\beta_{22} - \beta_{32})\left|\Delta y_t\right| \\
& + (\delta_{21} - \delta_{31})\Delta u_{t-1} + (\delta_{22} - \delta_{32})\left|\Delta u_{t-1}\right| + (\varepsilon_{2t} - \varepsilon_{3t})
\end{aligned} \tag{28}$$

[8]The specification adopted here follows Zakoïan (1994) and Glosten, et al. (1993) modeling of the asymmetric response of stock prices to good/bad news.

Notice that while the coefficients linking net flows between employment and unemployment do not appear explicitly in (28), all flows have a role as they are embodied in the lagged change in the unemployment rate.

2.2.2 Testable Hypothesis

Our specification shows that Okun's coefficient evolves with the state of the labor market (u_{t-1}). The coefficient will be a constant when $[(\beta_{31} - \beta_{21}) + (\beta_{32} - \beta_{22})] = 0$. This is the special case when the effect of growth on nu_t offsets the effect of growth on en_t; alternatively, when growth has no effect on nu_t and en_t. Put another way, growth has only significant effects on the net flow eu and moreover β_{11} is a constant. Note too that if either β_{11} and/or β_{21} and/or β_{31} is significant, then the Okun coefficient will be asymmetric.

The other testable hypothesis is that the relationship changes as a result of changes in the intercept and other terms which reflect autoregressive behavior and responses to lagged labor market conditions. The significance of the coefficients (α_3, α_2) and $(\delta_{11}, \delta_{21}, \delta_{31}, \delta_{12}, \delta_{22}, \delta_{32})$ can again be used to test the relevance of autoregressive behavior and asymmetry in adjustments.

Thus our flows approach to investigating Okun's Law allows us to link the relationship between growth and unemployment more tightly. It also provides a way to view Okun's coefficient as possibly time-varying with asymmetric responses. This is because our framework nests testable hypothesis to investigate whether Okun's coefficient can be treated as a constant/time-varying and/or as symmetric/asymmetric.

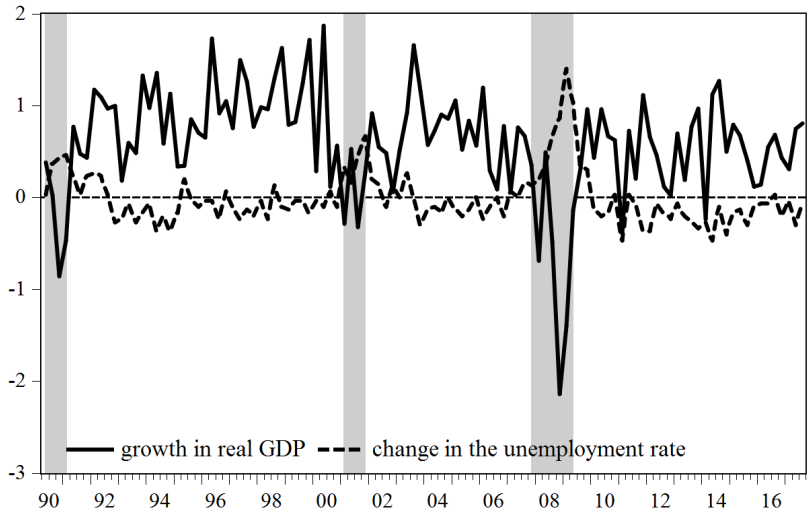
3 Empirical Analysis

3.1 Data

Figure 1 shows the quarterly growth rate in GDP (measured as a percentage)[9] and the evolution of the change in the unemployment rate (also in percentage terms) for persons in the US over the period 1990:2 – 2017:3. The start date is conditioned by the availability of the BLS stock-consistent flows data.

[9]Real GDP data is U.S. Bureau of Economic Analysis, Real Gross Domestic Product, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPC1 , November 6, 2017. The series is in Billions of Chained 2009 Dollars, Seasonally Adjusted Annual Rate. The growth rate is measured as the change in real GDP (quarter on previous quarter) expressed as a percentage.

Figure 1: Changes in the Unemployment Rate and Growth in Real GDP: 1990:2-2017:3



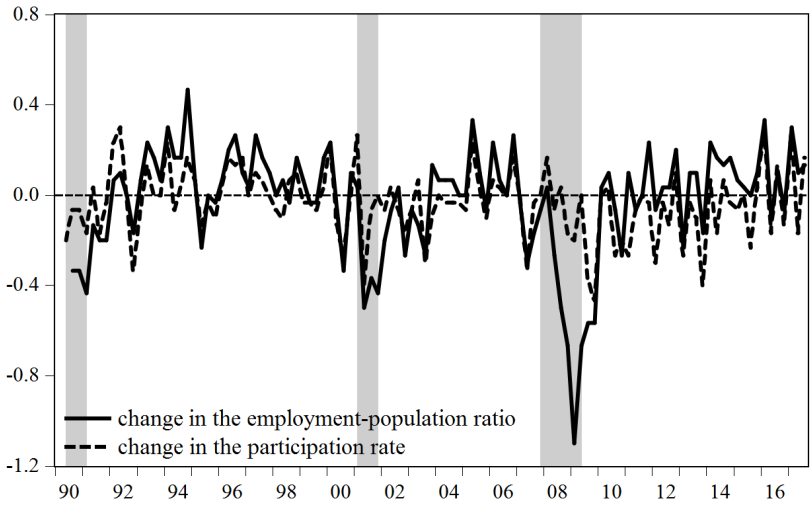
Note: Shaded areas are the NBER recession periods

The sharp rise in unemployment during the three downturns in the US (in our sample period, they occurred in the early 90's, early 00's and during the Great Recession) are evident as is the fact that, in contrast to the rapid rise in unemployment in contractions, unemployment improves only gradually during expansions.

For completeness, Figure 2 shows the change in the participation rate and the employment-population ratio over the sample period 1990:2 - 2017:3. The main point to note is the negative change in participation during the NBER recession periods and in the years following the Great Recession.

Turning to the flows, our data source is a BLS data set on stock-consistent flows. The BLS have been producing worker flows data from the Current Population Survey (CPS), a monthly sample survey of approximately 60,000 households, since 1990. In any given month, the BLS survey shows the six possible flows associated with changing states between employment (E), unemployment (U) and being not in the labor force (N). However, the unemployment rate derived from the seasonally adjusted monthly estimates of the "gross flows" EU, EN, UE, UN, NE and NU were not consistent with estimates of changes derived from the reported monthly labor force stock estimates. Recently, the BLS have developed methods to reconcile the flows and stock data. Since October 2007, the Bureau of Labor Statistics (BLS) has made available to researchers estimates of gross

Figure 2: Changes in the Participation Rate and the Employment-Population Ratio: 1990:2-2017:3



Note: Shaded areas are the NBER recession periods

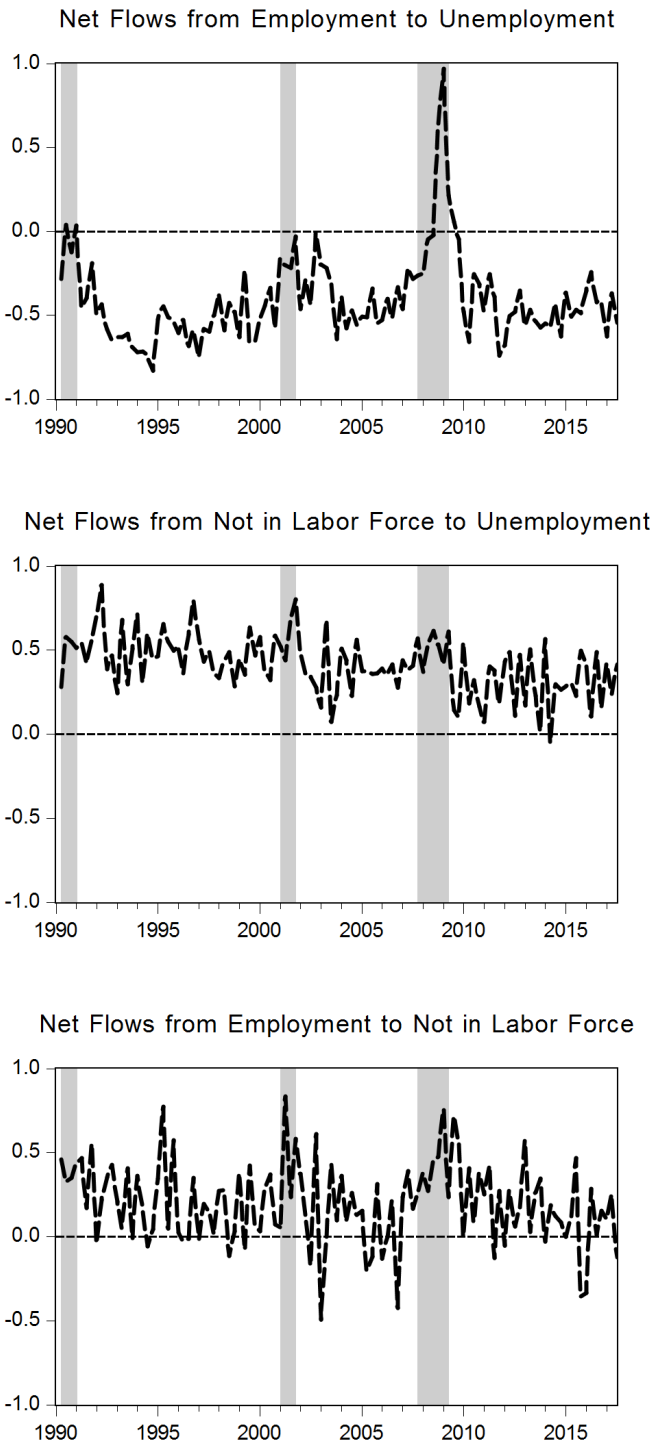
flows consistent with stocks in the CPS. These series extend from February 1990 to the present.[10] The net flows can be easily computed from data for the gross flows. Figure 3 shows the evolution of each of the net flows over the period 1990:2-2017:3.[11]

We see that: (i) The balance of flows from employment to unemployment is negative ($eu < 0$), except during two quarters in the early nineties and especially during the Great Recession when there was a marked rise; (ii) Except for 2014:2, the balance of flows from not in the labor force to unemployment is positive (nu), and this is the case even in downturns, and; (iii) In most quarters the balance of flows from employment to not in the labor force (en) is positive. Also given (13), we see that the negative direction of change in the participation rate occurred because en_t is greater than nu_t; that is there were more net flows from employment to not in the labor force than net flows from not in the labor force to unemployment. The positive $(en_t - nu_t)$ added to an increase in the

[10]Further information on the BLS's stock-consistent data set may be found in Frazis et al.(2005). The (seasonally adjusted) CPS flows data are publicly available on the Internet at http://www.bls.gov/cps/cps_flows.htm. For examples of published work using this data set see: Barnichon and Nekarda (2012), Boon et al.(2008), Demiralp et al.(2011), Dixon et al.(2011) and Gyourko and Tracy (2014).

[11]The BLS notes that, in January 2000, the large flow from "marginal" to employment, to account for population changes, is affected by "changes associated with population controls". We checked the influence of this one outlier (in a sample of 330 quarterly observations) and found that it had no significant effect on the analysis.

Figure 3: Net Flows: Employment to Unemployment, Not in the labor force to Unemployment and Employment to Not in the Labor Force: 1990:2-2017:3



Note: Shaded areas are the NBER recession periods

unemployment rate by lowering the labor force (*ceteris paribus*).

Note too that the average values of the net-flows (eu, nu, en) are: (-0.474, 0.399, 0.171) during expansionary periods and (0.021; 0.515; 0.394) during the NBER dated contractionary periods. The corresponding average growth and unemployment rates ($\Delta y_t, \Delta u_t$) were (0.744, -0.082) and (-0.343, 0.488). What these show is that there is *prima facie* evidence of time-variation and asymmetry in the net flows.

Table 1: SUR Results; Equations (23)-(25)

	eu		nu		en	
Constant	-0.373	(0.037)***	0.425	(0.039)***	0.178	(0.053)***
Δy_t	-0.248	(0.033)***	-0.019	(0.035)	-0.054	(0.047)
$\lvert\Delta y_t\rvert$	0.114	(0.042)***	-0.008	(0.045)	0.041	(0.061)
Δu_{t-1}	0.312	(0.067)***	0.063	(0.072)	0.185	(0.097)**
$\lvert\Delta u_{t-1}\rvert$	0.140	(0.093)	0.030	(0.100)	0.123	(0.134)
R^2	0.624		0.030		0.128	

Notes: Heteroskedastic and autocorrelation (HAC) robust standard errors (in parentheses) are reported below the estimated values of the coefficients. *** (**) indicates the coefficient is significantly different from zero at the 1% (5%) level. The recursive residuals show that the system is stable. Wald test statistic for: $(\widehat{\alpha}_1 + \widehat{\alpha}_2 = 0)$is 1.12 ($p$-value=0.29). Wald test statistic for: $(\widehat{\alpha}_3 - \widehat{\alpha}_2 = 0)$is 12.88 ($p$-value=0.00)

3.2 SUR model of Labor flows and the GDP growth rate

Table 1 reports the SUR (seemingly unrelated regression) results for the quarterly net flows based on equations (23)-(25). The results show that all flows have significant intercept terms. Only eu responds (negatively) to the contemporaneous growth of real GDP and with a significant asymmetric effect (an increase in growth reduces eu by 0.134, while a falling growth increases eu by 0.362). Neither net flows nu nor en are directly responsive to growth. An increase in the lagged unemployment rate affects positively the net flows from employment to not-in-the-labor-force en but not the net flows from not-in-the-labor-force to unemployment nu. The net flow, eu, also reacts to the lagged unemployment rate.

With reference to equation (26), the insignificant coefficients are: $\beta_{21}, \beta_{22}, \beta_{31}, \beta_{32}$,

$\delta_{12}, \delta_{21}, \delta_{22}, \delta_{32}$, meaning that, for this data set, the empirical model is effectively:

$$\begin{aligned}\Delta u_t = (\widehat{\alpha}_1 + \widehat{\alpha}_2) + (\widehat{\alpha}_3 - \widehat{\alpha}_2)u_{t-1} + \widehat{\beta}_{11}\Delta y_t + \widehat{\beta}_{12}\left|\Delta y_t\right| \\ + (\widehat{\delta}_{11} + \widehat{\delta}_{31}u_{t-1})\Delta u_{t-1} + \widehat{\nu}_t \end{aligned} \tag{29}$$

where $\widehat{\nu}_t$ are all effects not explicitly stated (i.e. from the insignificant variables and the estimated residuals). Equation (29) highlights an important empirical point, namely that Okun models which do not allow for the lagged effect of the level of the unemployment rate are mis-specified (and this is irrespective of how lagged effects are introduced). For a given shock to growth, the effect on the change in the unemployment rate also depends on the level of u_{t-1}.

Focusing on the impact of growth on the change in the unemployment rate, our results show that the US Okun coefficient is asymmetric (i.e., it depends on whether growth is positive or negative), but it is not time-varying (i.e., it does not vary with u_{t-1}).

$$\Delta y_t > 0 : \widehat{\beta}_t^+ = \widehat{\beta}_{11} + \widehat{\beta}_{12} \tag{30}$$

$$\Delta y_t < 0 : \widehat{\beta}_t^- = -\widehat{\beta}_{11} + \widehat{\beta}_{12} \tag{31}$$

In contrast, the results also show that the dynamics are time-varying, even though the reaction of the net flows to the lagged unemployment rate are not asymmetric.[12]

For completeness, our results (focusing only on the significant coefficients and ignoring population effects) indicate that the participation rate responds to the lagged change in the unemployment rate (via *en*)

$$\frac{\Delta p_t}{p_t} = (\widehat{\alpha}_2 - \widehat{\alpha}_3) - \widehat{\delta}_{31}\Delta u_{t-1} + \widehat{\eta}_t \tag{32}$$

where $\widehat{\eta}_t$ are all effects not explicitly stated (i.e., from the insignificant variables and the estimated residuals). Note that the estimated value of $\widehat{\delta}_{31}$ is positive indicating, as expected, that the change in the participation rate is inversely related to the (lagged) change in the unemployment rate.

[12]For more on the time-variation in the Okun relationship, see Appendix 2.

3.3 Contractions and Expansions

The participation and unemployment rates are determined simultaneously, as a consequence of changes in the net flows. To understand the extent to which these rates change in contractions and expansions, we simulated the model and the dynamic paths are shown in Figure 4. The model is based on a restricted version which contains only significant coefficients, purely to highlight the main effects. The figures for the net flows show that they stabilize and the directions of change are as expected. Observe that the dynamic paths of *eu* and *ne* are asymmetric, but *nu*, the net flows from inactivity to unemployment, is unaffected by growth or by lagged labor market conditions.

We see that, following a temporary shock to GDP growth, there are impact effects to the net flows from employment to unemployment, *eu*, but the effects are asymmetric depending on whether the shock to growth is a 1 percentage point fall in GDP growth (contractions) or a 1 percentage point increase in GDP growth (expansions). Subsequent dynamics show that both net flows *eu* and *en* (net flows from employment to not in the labor force) react to lagged labor market conditions.[13]

Using the mean sample values as starting points, we find estimates of asymmetry as follows. The unemployment rate commences at 6.01% and stabilizes at 6.62% in a recession scenario and at 5.78% in an expansion scenario. The change in the unemployment rate to a 1% shock in growth is 0.61% for a contractionary shock and 0.24% for a positive growth shock. The effect during downturns is more than twice as big as during upturns.[14]

Many possible explanations for this asymmetry have been proposed. They include: the scarring effects of unemployment and skill loss with the result that the attractiveness of an employee varies with the (average) duration of unemployment; the presence of fixed costs of employment and associated with that labor hoarding so that as a recovery gets underway increased output results (in part) by raising the hours of incumbents rather than new hires; and vintage effects as older labor-intensive plant/firms are more likely to

[13]The extensive literature on Okun's law suggests that the relevant explanation(s) for asymmetry in the Okun coefficient must be to do with differences in the way average hours, labor productivity, labor force participation and the process by which workers are matched to jobs respond to positive or negative shocks to GDP. In his 1962 paper Okun himself focused attention on the first three items, while more recent literature has also examined asymmetries resulting from differences in job hiring and search practices, including scarring effects of unemployment.

[14]Note that, these results based on stock-consistent flows are not dissimilar to the results in the Ball et al. (2017) study which showed that the Okun coefficient was asymmetric with estimated values of -0.248 in contractions and -0.535 in other periods (p. 1422, Table 3 last column). Our study takes these results further by identifying the net flows that matter.

be 'knocked out' in the recession while newer less-labor intensive firms survive resulting in more jobs lost in a recession than, for the same rise in output, jobs created in a recovery. Further analysis is beyond the scope of this paper.

The starting value for the participation rate in the simulation is 65.59% and it stabilizes at a lower value, 65.47%, for a negative shock to growth and at a higher value, 65.63%, for a positive shock to growth. The discouraged worker effect (a fall in the participation rate of 0.12 following a negative shock to growth) is larger in absolute terms than the encouraged worker effect (a rise of 0.04 in the participation rate following a positive shock to growth).

The employment-population ratio reflects the combined change in the unemployment and participation rates. The initial value of the employment-population ratio is 61.64% and it stabilizes to 61.14% for a contractionary shock and to 61.84% for an expansionary shock. The long run rise of 0.20 in the event of a positive shock to GDP is smaller in absolute terms than the long run fall of 0.50 in the ratio following a negative shock to GDP reflecting the greater variation in the unemployment rate relative to the participation rate.

3.4 Labor Market Indicators

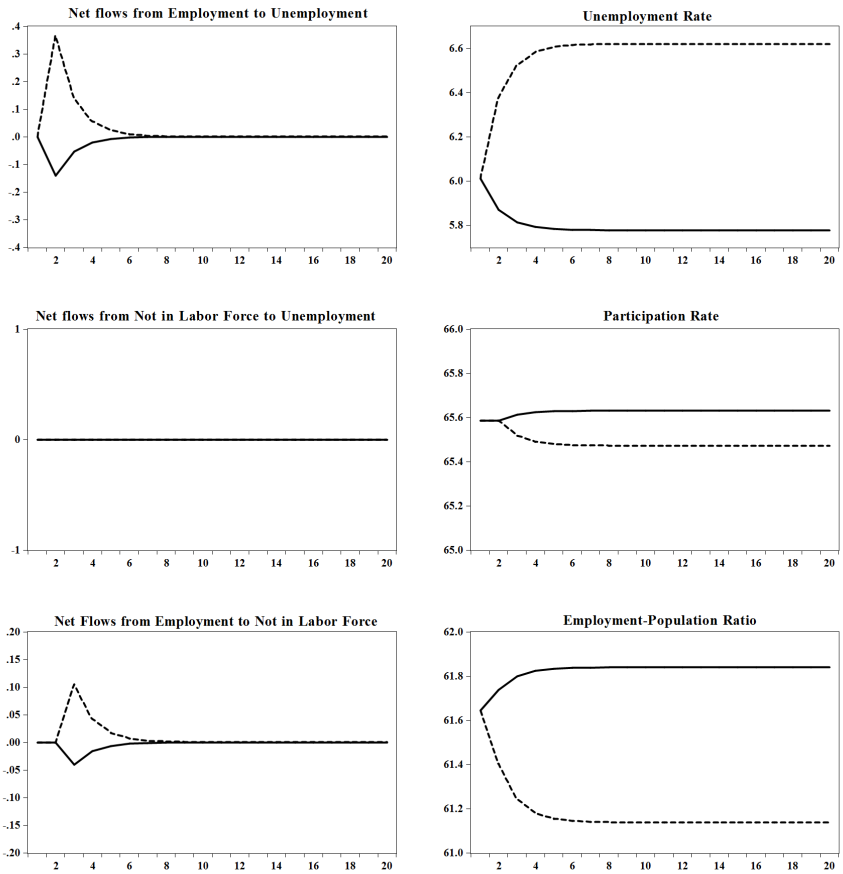
Our model also allows us to compare the predicted with the actual evolution of the unemployment rate, the participation rate and the employment population ratio. The top graph in Figure 5 plots the unemployment rate and it is obvious that our model based on labor market flows is able to track actual developments, including the Great Recession in the 2010s, quite closely.

The middle graph of Figure 5 shows the tracking performance of the model for the changes and the levels of the participation rate. Note here that it is necessary to account for population changes and the modification is set out in the Appendix. As we can see from the the Figure, our model-derived participation rate also tracks actual developments quite closely including the remarkable drop after the Great Recession. Our analysis thus supports Erceg and Levin (2014) who argue that "cyclical factors account for the bulk of the post-2007 decline in the US labor force participation rate."[15]

Changes in the participation rate are not affected by the net flows from employment to unemployment but is affected by the net flows from not in the labor force to unemployment and the net flows from employment to not in the labor force. However,

[15]See also Krueger (2017) and Elsby et al. (2015) on the drop in the US participation rate.

Figure 4: Simulated Net Flows, Unemployment and Participation Rates and the Employment-Population Ratio

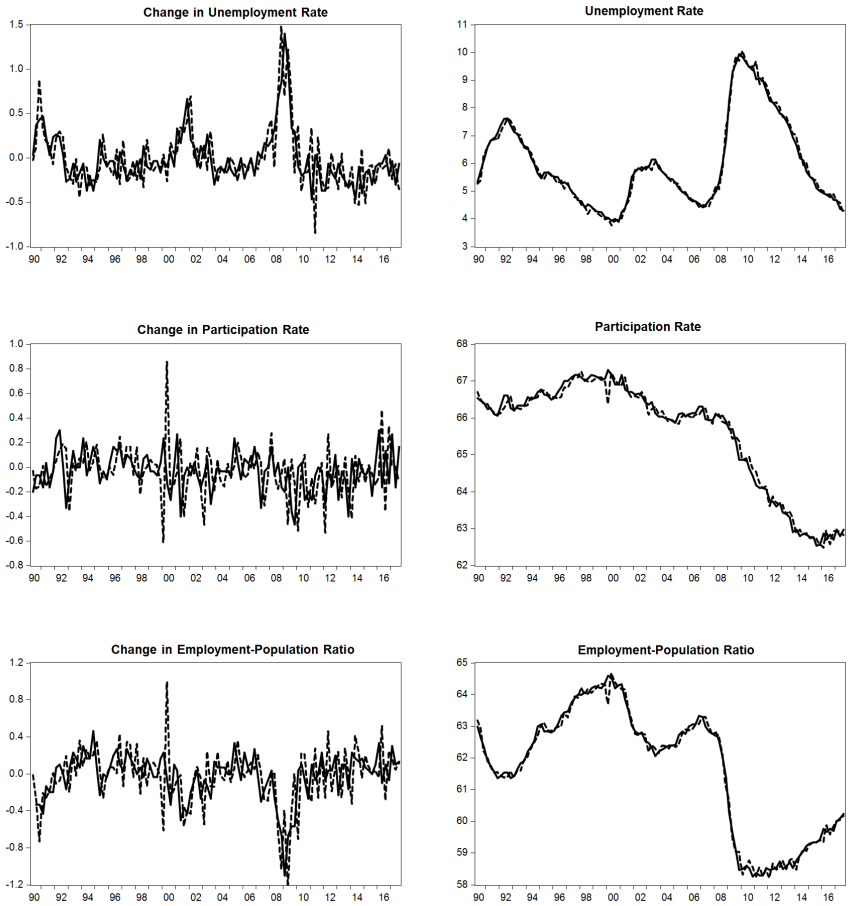


Note: Solid lines: contractionary shock; dashed lines: expansionary shock

economic growth is not a significant driver of these net flows in and out of the labor force and while population growth shifts down the participation rate, the cyclical nature of the participation rate appears to be driven mainly by responses to the lagged change in the unemployment rate on the net flow from employment to not in the labor force. Apparently, there is a discouraged worker effect in the U.S. labor market that induces workers to leave the labor force when unemployment increases. However this does not work through an increase in the net flow from unemployment to not in the labor force but rather through an increase in the net flow from employment to not in the labor force.

For completeness, the bottom graph of Figure 5 shows that our model is able to track the developments in the employment population ratio quite well.

Figure 5: Unemployment Rate, Participation Rate and Employment Population Rate: Actual and Predictions from the Model; 1990:2-2017:3



Note: Solid line: actual; dashed line: predictions

4 Concluding Remarks

The aim of the paper was to increase our understanding of the causal relationships behind Okun's law linking the change in the unemployment rate and the growth of real GDP. We proposed a labor flows framework with well-defined specifications of the linkages between the flows and the summary statistics - unemployment and participation rates and the employment population ratio - to understand the dynamics between growth and labor market behavior. Our econometric model allows the Okun coefficient to be time-varying and thus to evolve endogenously and asymmetrically over contractions and expansions. However, the framework is flexible and nests various possibilities for the Okun coefficient including the case when it is a constant and when it is not asymmetric. The approach

obviates the need to rely on (ex-post) dating of recession periods.

The empirical analysis was based on the BLS stock-consistent labor market flows data for the sample period 1990:2-2017:3. Our empirical analysis shows that the US Okun coefficient is not time-varying because neither net flows from unemployment to not in the labor force nor from employment to not in the labor force are sensitive to changes in growth. However, Okun's coefficient exhibits asymmetry being larger in contractionary periods than expansionary periods because the net flows between employment and unemployment respond differently to positive and negative changes in growth.

Simulating the model with a shock to output growth, we find that labor market flows are affected such that the long run Okun coefficient (the change in the unemployment rate in response to a 1% change in growth) is 0.61 for a negative shock and 0.24 for a positive shock. This result likely reflects the observation that it is easier to layoff workers in recessions than it is to hire workers in a boom because employers tend to be hesitant about adjusting their workforce along the extensive margin and may prefer, in the early stages of recovery, to expand along the intensive margin of labor supply by increasing overtime hours.

We also generated in-sample forecasts to show the tracking performance of model for the changes and levels of the unemployment rate, the participation rate and the employment population ratio. The fitted series show clearly that during contractionary periods, the increase in the unemployment rate is exacerbated by the stronger response of net flows to not in the labor force from employment. In other words, understanding net flows between the three states - employment, unemployment and not in the labor force - and the nature of the simultaneous change in participation as well as the lagged responses to labor market conditions - is essential to fully understand Okun's Law between changes in the unemployment rate and growth.

To conclude, we have presented an approach based on labor flows which facilitates a deeper understanding of the relationship known as Okun's Law. Our labor flows framework not only provides a natural (testable) specification to explain why an Okun coefficient may be (potentially) time-varying and asymmetric, but it also identifies the underlying flows that are the critical to explaining the time variation and asymmetry.

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Appendix 1: Allowing for population changes

In our theory section (2.1), we ignore population growth, i.e. we assume that the population at the beginning of the month is the same as the population at the end of the month: $P_{t-1} = P_t$. This simplifies the math but is not stock-consistent as in reality population is not a constant. Let g_t be the rate of growth in the population.

$$P_t = (1 + g_t)P_{t-1}$$
$$g_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

Then, the stock consistent definition of the change in the participation rate is

$$\begin{aligned}\Delta p_t &= \frac{L_t}{P_t} - \frac{L_{t-1}}{P_{t-1}}\frac{P_t}{P_t} = \frac{1}{P_t}\left(L_t - L_{t-1}(1 + g_t)\right) \\ &= \frac{(L_t - L_{t-1} - L_{t-1}g_t)}{P_t} = \frac{\Delta L_t}{P_t} - \frac{L_{t-1}g_t}{P_t}\end{aligned}$$

Putting this in net flow terms:

$$\begin{aligned}\frac{\Delta p_t}{p_t} &= \frac{\Delta p_t}{L_t/P_t} = \frac{\Delta L_t}{L_t} - \frac{L_{t-1}}{L_t}g_t \\ &= (nu_t - en_t) - \frac{L_{t-1}}{L_t}g_t\end{aligned}$$

shows that predictions of $\frac{\Delta p_t}{p_t}$ using $(nu_t - en_t)$ will be (systematically) greater than actual by $\frac{L_{t-1}}{L_t}g_t$. Treating g_t as exogenously determined and manipulating the terms gives:

$$\frac{\Delta p_t}{p_t} = (nu_t - en_t)(1 + g_t) - g_t$$

In our predictions of the participation rate represented in Figure 5, we have taken actual population growth into account:

$$\widehat{p}_t = \frac{p_{t-1}}{(1 - \widehat{\Phi}_t)}$$
$$\widehat{\Phi}_t = (\widehat{nu}_t - \widehat{en}_t)(1 + g_t) - g_t$$

Appendix 2: Time-varying Okun coefficient

We propose a deeper understanding of Okun's Law by looking at flows and our encompassing framework allows us to explore the nature of the time variation in the Okun. relationship. Our econometric model specifies the lagged unemployment rate as the driver of time-variation, and the model differentiates between coefficients that are time-varying and asymmetric (as in being different in different regimes). The Okun relationship will be stable if and when the Okun coefficient is constant over time, but it can also be asymmetric (regime-dependent).

Our computation of the time variation in the Okun coefficient/relationship is similar in spirit to the application of rolling regressions and regime-based approaches (such as regime dummies or switching between regimes). It is different from a basic time-varying parameter (state-space model) of Okun's Law which assumes that the Okun coefficient evolves like a random walk. Our approach is clearer about the source of the time-variation and the nature of the time variation.

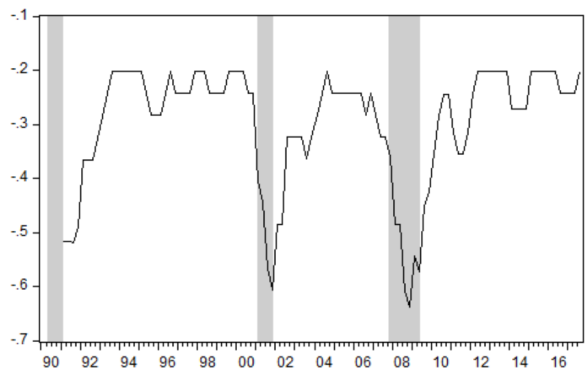
Our estimated model shows that the unemployment rate can be attributable to a shift factor (intercept term); changes in growth (the impact Okun coefficient); dynamic adjustments and idiosyncratic shocks. According to our estimated results, the Okun relationship is stable (ie constant) but with asymmetric Okun coefficients.

To see this, write equation (26) simply as below and compute the implied steady-state (when $t = t - 1$) Okun parameter β_t^* at each point in time (bearing in mind the role of $|\Delta y_t|$ and $|\Delta u|$ effects) as:

$$\Delta u_t = \alpha_t + \beta_t \Delta y_t + \delta_t \Delta u_{t-1} + \varepsilon_t$$
$$\beta_t^* = \frac{\beta_t}{(1 - \delta_t)}$$

Figure 6 plots the underlying (ie. the 4-quarter moving averages) evolution of $\widehat{\beta}_t^*$ for our estimated model. Our results shows clearly that the Okun coefficient is asymmetric, averaging around negative 0.2 in periods of positive growth and about negative 0.6 in recessions. However, it is also clear that the Okun relationship between output growth and the change in the unemployment rate is stable (albeit with regime-shifts).

Figure 6: Okun's coefficient (derived from the labor flows model)



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