Kiel

Working Papers

Kiel Institute
for the World Economy

Sector-Specific Productivity Shocks in a Matching Model

by Dennis Wesselbaum

No. 1585 | May 2010

Web: www.ifw-kiel.de

Kiel Working Paper No. 1585 | May 2010

Sector-Specific Productivity Shocks in a Matching Model

Dennis Wesselbaum

Abstract:
Endogenous separation matching models have the shortcoming that they are barely able to replicate the Beveridge curve (i.e. the negative correlation between unemployment and vacancies) and business cycle statistics jointly. This paper builds upon the sectoral shock literature and combines its insights with the standard endogenous separation matching approach. We show that sectoral shocks can generate an aggregate Beveridge curve and perform reasonably well in explaining business cycle facts, especially compared to the one-sector baseline model.

Keywords: Beveridge Curve, Endogenous Separations, Sectoral Productivity Shock.

JEL classification: E24, E32, J64.

The Kiel Institute for the World Economy &
EABCN

E-mail:
dennis.wesselbaum@ifw-kiel.de

Sector-Specific Productivity Shocks in a Matching Model*

Dennis Wesselbaum[†]

Kiel Institute for the World Economy and EABCN

May 20, 2010

Abstract

Endogenous separation matching models have the shortcoming that they are barely able to replicate the Beveridge curve (i.e. the negative correlation between unemployment and vacancies) and business cycle statistics jointly. This paper builds upon the sectoral shock literature and combines its insights with the standard endogenous separation matching approach. We show that the endogenous matching model with sectoral shocks can generate an aggregate Beveridge curve and performs reasonably well in explaining business cycle facts, especially compared to the one-sector baseline model.

Keywords: Beveridge Curve, Endogenous Separations, Sectoral Productivity Shock.
JEL classification: E24, E32, J64.

* I would like to thank Alessio Brown, Chris Reicher, Björn van Roye, and Lorenza Rossi for highly valuable comments and suggestions. In addition, I am grateful for comments from seminar participants at the Kiel Institute. Furthermore, I would like to thank the EES network for financial support. Main part of this research was conducted during my visit of the Department of Economics at the University of Pavia, whose hospitality is gratefully acknowledged. The opinions and analyses in this paper are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Kiel Institute.
† Contact: dennis.wesselbaum@ifw-kiel.de

1. Introduction

An essential question in the design of matching models is the definition of the firm's exit site. In the recent matching literature there is no consensus on the proper determination of the separation margin, whether it is exogenous or endogenous. In the seminal contributions from Shimer (2005) and Hagedorn and Manovskii (2008) separations are determined exogenously and hence are not subject to incentives. In contrast, Mortensen and Pissarides (1994) and Mortensen and Nagypál (2007) include the fact that firm and worker may respond to - cyclical - changes in the economic environment and, as a consequence, end their relationship. Fujita et al. (2007) and Fujita and Ramey (2007, 2008) empirical evidence seems to favor endogenous separations, since the standard deviation of the separation rate in the data is 5.8 %. Furthermore, endogenous separations can explain the negative correlation of the separation rate with productivity and the standard deviation of unemployment.[1] In addition, Balleer (2009) shows that the separation rate increases after a positive technology shock and that the standard model generates the volatility of these variables conditional on technology shocks. Along this line, Barnichon (2009) finds that around business cycle turning points the separation rate is causative for most of unemployment movements.

The assessment of matching models can happen along two dimensions, namely the ability to replicate empirical (i) standard deviations, and (ii) correlations. Ramey (2008) shows that the standard endogenous separation model is not able to replicate the negative correlation between unemployment and vacancies, i.e. the Beveridge curve, while the standard exogenous separation model is able to replicate this fact. In addition, he shows that the introduction of on-the-job search creates a very strong Beveridge curve because "procyclical movements in the number of employed searchers lead to procyclical changes in vacancy posting incentives". Along this line, Krause and Lubik (2007) show that real wage rigidity also creates a Beveridge curve, because surpluses are larger over the cycle compared to the flexible wage regime, leading firms to post more vacancies. However, this model is barely able to match the empirical standard deviations, a problem stressed by Shimer (2005) within the exogenous separation model. We can conclude that the endogenous matching model has shortcomings in explaining volatilities and correlations jointly. We propose a different, so far rather neglected, solution by introducing a - frictional - two-sector production process. Some real business cycle theories explain unemployment by sectoral shocks that propagate through imperfect la-

[1] To be more precise, the elasticities of unemployment, the separation rate respectively, to productivity are closer to their empirical pendants assuming endogenous separation rates.

bor markets.[2] In contrast to Lucas (1977), sectoral shocks do not average out - and hence have aggregate effects - because (i) reallocation is costly and time-consuming and (ii) information is asymmetrically distributed. Lilien's (1982) seminal contribution focuses on the macroeconomic effects of reallocation shocks. His sectoral shift hypothesis highlights the allocative effects of shocks affecting the composition of demand. Lilien finds that around 50 % of fluctuations in the unemployment rate is caused by structural shifts in labor demand within the economy. In contrast, Abraham and Katz (1986) argue that the positive correlation between the dispersion of employment growth rates and the unemployment rate is caused by fluctuations in aggregate demand. Therefore, the relevance of inter-sectoral labor reallocation as a source of aggregate unemployment fluctuations is still controversially discussed.
We build an economy with one representative firm and a frictional labor market. The representative firm contains two sectors, (i) a manufacturing sector and (ii) a service sector. Output is produced with a combination of both inputs. The introduction of search and matching frictions in both sectors implies that firms can not instantaneously find a new worker and therefore average out is not likely to appear. Consistently, we expect to observe aggregate effects of sectoral shocks. We start by discussing the flexible price core of our model. Later on, we consider the more realistic case with sticky prices and evaluate the model's performance along both discussed dimension.
We find that the manufacturing sectoral productivity shock creates an aggregate Beveridge curve but still creates too less volatility compared to the data, but increases the volatility compared to the one-sector reference model. The aggregate shock creates much more volatility as in the one-sector model but fails to replicate the Beveridge curve. A combination of both shocks replicates volatilities and cyclicality found in the data reasonably well.
The paper is structured as follows. The next section scrutinizes sectoral U.S. data to assess our simulation results. Section 3 develops the model and section 4 discusses the shocks in the RBC core and the sticky price version. Section 5 concludes.

2. Data Analysis

This section scrutinizes U.S. data to generate a transparent basis for the assessment of our model. We use quarterly data provided by the U.S. Bureau of Labor Statistics from 2001:Q1 till 2009:Q4 (36 observations). For the sectoral vacancy rates we use time

[2] See Hamilton (1988) or Lucas and Prescott (1974).

series provided by the JOLTS database. to be precise, we choose total job openings in the manufacturing sector (JTU30000000JOR) and total job openings in the professional and service sector (JTU54009900JOR). Furthermore, we use the time series for unemployed manufacturing (LNU04032232) and professional and service (LNU04032239) workers from the Current Population Survey (CPS). All time series are written in logarithmic scale and are detrend with a Hodrick-Prescott filter with smoothing parameter $\lambda = 100.000$ as proposed by Shimer (2005). Our results are presented in Table 1. Both sectors show a strong Beveridge curve relation, i.e. a negative correlation between unemployment and vacancies. In the manufacturing sector we find a value of -0.92, while the service sector shows a slightly lower value of -0.75. Unemployment in the manufacturing sector is almost five times as volatile as output and nearly twice as volatile as unemployment in the service sector. Consistently, we find that vacancy posting has a higher standard deviation in the manufacturing sector as in the service sector. As labor market tightness is a product of these two variables, it is not surprising, that labor market tightness is more than twice as volatile in the manufacturing sector as in the service sector and almost 16 times as volatile as output. In general, we can draw the conclusion that the manufacturing sector is much more volatile as the service sector.

3. Model Derivation

Our model economy is based upon the contributions from Mortensen and Pissarides (1994) and den Haan et al. (2000). Households maximize their utility by choosing the optimal consumption path of a CES aggregate of differentiated products. Firms maximize profits by setting prices and choosing the optimal mixture of workers in the sectors manufacturing and service, subject to Rotemberg (1982) price adjustment costs and labor turnover costs. Separations are driven by job-specific productivity shocks, that are drawn from a time-invariant distribution. These shocks generate a flow of workers into unemployment while the transition process from unemployment to employment is subject to search frictions, characterized by a matching function.

3.1. Preferences

Our discrete-time economy is populated with two types of workers. Therefore, there are two types of representative households who maximize utility given by

$$U^x = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma} - 1}{1-\sigma} \right], \tag{1}$$

where $x \in m, s$ is the index for the worker's sector and the degree of risk aversion is given by σ. We assume that a household consists of a continuum of members, inelastically suppling one unit of labor and being represented by the unit interval. In addition, household members insure each other against income fluctuations.[3] The intertemporal budget constraint can be written as

$$C_t + \frac{B_t}{P_t} = \mathcal{W}_t^x + R_{t-1}\frac{B_{t-1}}{P_t} + b^x u_t + \Pi_t + T_t. \tag{2}$$

b^x corresponds to unemployment benefits and $\mathcal{W}_t^x$ is labor income. B_t is Bond holding which pays a gross interest rate R_t, Π_t are aggregate profits and T_t are lump sum transfers from the government. The FOC of the household problem is the standard Euler equation and is given by

$$C_t^{-\sigma} \;=\; \beta R_t E_t \left[\frac{P_t}{P_{t+1}} C_{t+1}^{-\sigma} \right]. \tag{3}$$

3.2. Search and Matching

The firm searches for workers on two discrete and closed markets.[4] One market contains all workers in the manufacturing sector, as the other contains all workers in the service sector. This assumption allows us to avoid an aggregate matching function and to consider a more general approach (see Tapp (2007)). As a consequence, we can account for differences in vacancy filling rates across sectors, found by Davis et al. (2007). Consistently, we abstract from movements between sectors. Labor market frictions are modeled via a Cobb-Douglas type matching function with constant returns to scale $m(u_t^x, v_t^x) = m(u_t^x)^{\mu}(v_t^x)^{1-\mu}$. The function gives the number of new employment relationships at the beginning of the next period. Where u_t^x is the number of unemployed

[3]See Merz (1995).

[4]See Davis (2001) for ex ante labor sorting into separate search markets. In general, the ability of workers to switch sectors is limited due to specific skills, initial education and employment protection legislation as shown by Lamo et al. (2006). In addition, see Davis and Haltiwanger (2001).

worker and v_t^x is the number of open vacancies, assumed to lie on the unit interval. Where $\mu \in (0,1)$ is the elasticity of the matching function with respect to unemployment and the matching efficiency is governed by $m > 0$. The underlying homogeneity assumption leads to the probability of a vacancy being filled in the next period, i.e. $q(\theta_t^x) = m(\theta_t^x)^{-\mu}$. Labor market tightness, given by $\theta_t^x = v_t^x/u_t^x$ is a key point in explaining equilibrium unemployment, due to the fact that it contains the congestion externality, which follows from the fact that, if a firm posts a vacancy it decreases simultaneously the probability for other firms to fill a vacancy. Furthermore, an additional searcher causes negative search externalities for other searchers, i.e. reduces the job finding probability of all other searchers.

The firm's exit site is characterized by endogenous separations. The total number of separations in each sector, at firm i is given by $\rho^x(\tilde{a}_{it}^x) = F(\tilde{a}_{it}^x)$, where $\tilde{a}_{it}^x$ is the cut-off point and $F(\cdot)$ is a time-invariant distribution with positive support $f(\cdot)$. ω^x is the mean of the distribution and ς^x is the dispersion of the function. Connecting the results for job creation and the job destruction enables us to determine the evolution of employment at firm i as

$$n_{it+1}^x = (1 - \rho_{it+1}^x)(n_{it}^x + v_{it}^x q(\theta_t^x)). \tag{4}$$

The firm is able to control the evolution of employment by adjusting the number of posted vacancies and by setting the critical threshold, which then influences the separation rate.

Aggregate unemployment is then given by

$$u_{it} = u_{it}^m + u_{it}^s, \tag{5}$$

while aggregate matches and vacancies evolve as

$$m_{it}^{agg} = m_{it}^m + m_{it}^s, \tag{6}$$

$$v_{it}^{agg} = v_{it}^m + v_{it}^s, \tag{7}$$

$$\theta_{it}^{agg} = \frac{v_{it}^{agg}}{u_{it}^{agg}}. \tag{8}$$

3.3. Technology

If the matching process has been successful, production commences along the production function given by

$$y_{it} = A_t \left(y_{it}^m\right)^\alpha \left(y_{it}^s\right)^{1-\alpha}, \tag{9}$$

where the sector-specific production functions can be written as

$$y_{it}^x = A_t^x n_{it}^x \int_{\tilde{a}_{it}^x} a^x \frac{f(a^x)}{1-F(\tilde{a}_{it}^x)} da^x \equiv A_t^x n_{it}^x H(\tilde{a}_{it}^x). \tag{10}$$

While aggregate productivity A_t and sectoral "aggregate" productivities A_t^x are common to all firms, the specific idiosyncratic productivity a_{it}^x is idiosyncratic and every period it is drawn in advance of the production process from the corresponding distribution function.
The firm maximizes the present value of real profits given by

$$\Pi_{i0} = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[\frac{P_{it}}{P_t} y_{it} - \mathcal{W}_{it}^m - \mathcal{W}_{it}^s - c^m v_{it}^m - c^s v_{it}^s - \frac{\psi}{2} \left(\frac{P_{it}}{P_{it-1}} - \pi \right)^2 Y_t \right]. \tag{11}$$

Where the first term in parenthesis is real revenue, the second and the third term is the wage bill, which is given by the aggregate of individual wages

$$\mathcal{W}_{it}^x = n_{it}^x \int_{\tilde{a}_{it}^x} w_t^x(a^x) \frac{f(a^x)}{1-F(\tilde{a}_{it}^x)} da^x. \tag{12}$$

This follows from the fact that the wage is not identical for all workers, instead it depends on the idiosyncratic productivity and the worker's sector. The fourth and fifth term reflect the total costs of posting a vacancy. The latter term corresponds to Rotemberg (1982) price adjustment costs. The degree of these costs is measured by the parameter $\psi \geq 0$. The first-order conditions are

$$\partial n_{it}^x \; : \; \xi_t^x = \varphi_t A_t^x H(\tilde{a}_t^x) - \frac{\partial \mathcal{W}_t^x}{\partial n_t^x} + E_t \beta_{t+1} (1 - \rho_{t+1}^x) \xi_{t+1}^x, \tag{13}$$

$$\partial v_{it}^x \; : \; \frac{c^x}{q(\theta_t^x)} = E_t \beta_{t+1} (1 - \rho_{t+1}^x) \xi_{t+1}^x, \tag{14}$$

$$\partial P_{it} \; : \; 1 - \psi(\pi_t - \pi)\pi_t + E_t \beta_{t+1} \left[\psi(\pi_{t+1} - \pi)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right] = \epsilon(1 - \varphi_t). \tag{15}$$

The current period average value of workers across job-specific productivities and skill levels is given by ξ_t^x and φ_t reflects the real marginal costs. Combining (13) and (14) gives the job creation condition

$$\frac{c^x}{q(\theta_t^x)} = E_t\beta_{t+1}(1-\rho_{t+1}^x)\left[\varphi_{t+1}A_{t+1}^x H(\tilde{a}_{t+1}^x) - \frac{\partial \mathcal{W}_{t+1}^x}{\partial n_{t+1}^x} + \frac{c^x}{q(\theta_{t+1}^x)}\right]. \tag{16}$$

This condition reflects the hiring decision as a trade-off between the cost of a vacancy and the expected return. Where $1/q(\theta_t^x)$ is the duration of the relationship between firm and worker. The lower the probability of filling a vacancy, the longer the duration of existing contracts, because the firm is not able to replace the worker instantaneously. By multiplying the duration of the relationship with the hiring costs we arrive at the costs of a vacancy. If expected productivity rises, the right-hand side rises while the left-hand side on impact remains unchanged. The rise in expected revenue causes an incentive for the firm to post more vacancies, which increases labor market tightness. Since the probability that an open vacancy is filled is decreasing in the degree of labor market tightness the cost of posting vacancies increases and coherently lowers the incentives to post new vacancies leading to the new equilibrium.
Log-linearizing the last FOC around a zero inflation steady state gives the New Keynesian Phillips curve

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} + \kappa\hat{\varphi}_t, \tag{17}$$

where $\kappa = (\epsilon - 1)/\psi$ and $\hat{\varphi}_t$ reflects real marginal costs.
In the next section, we will determine the real wages and the cut-off points for idiosyncratic productivities.

3.4. Wage Determination

A match generates an economic rent which is splitted in individual Nash bargaining by maximizing the Nash product

$$w^x = argmax\left\{(W_t^x - U_t^x)^\eta (J_t^x - V_t)^{1-\eta}\right\} \tag{18}$$

Where the first term is the worker‘s surplus, the latter term is the firm‘s surplus and $0 \leq \eta \leq 1$ is the exogenously determined, constant relative bargaining power. U_t^x and V_t

are the worker's respectively the firm's threat points.[5] J_t^x is the asset value of a filled job for the firm and for the worker W_t^x is the asset value of being employed and accordingly U_t^x is the asset value of being unemployed.
The individual real wage satisfies the optimality condition

$$W_t^x(a_t^x) - U_t^x = \frac{\eta}{1-\eta} J_t^x(a_t^x). \tag{19}$$

To obtain an explicit expression for the individual real wage we have to determine the asset values and substitute them into the Nash bargaining solution (19). For the firm the asset value of the job depends on the real revenue, the real wage and if the job is not destroyed, the discounted future value. Otherwise the job is destroyed and hence has zero value. In terms of a Bellman equation the asset value is given by

$$J_t^x(a_t^x) = \varphi_t A_t^x a_t^x - w_t^x(a_t^x) + E_t\beta_{t+1}\left((1-\rho_{t+1}^x)\int_{\tilde{a}_{t+1}^x} J_{t+1}^x(a^x)\frac{f(a^x)}{1-F(\tilde{a}_{t+1}^x)}da^x\right). \tag{20}$$

The asset value of being employed for the worker consists of the real wage, the discounted continuation value and in case of separation the value of being unemployed

$$\begin{aligned} W_t^x(a_t^x) = w_t^x(a_t^x) + E_t\beta_{t+1}(1-\rho_{t+1}^x)\int_{\tilde{a}_{t+1}^x} W_{t+1}^x(a^x)\frac{f(a^x)}{1-F(\tilde{a}_{t+1}^x)}da^x \\ + E_t\beta_{t+1}\rho_{t+1}^x U_{t+1}^x. \end{aligned} \tag{21}$$

Analogously, the asset value of a job seeker is given by

$$\begin{aligned} U_t^x = b^x + E_t\beta_{t+1}\theta_t^x q(\theta_t^x)(1-\rho_{t+1}^x)\int_{\tilde{a}_{t+1}^x} W_{t+1}^x\frac{f(a^x)}{1-F(\tilde{a}_{t+1}^x)}da^x \\ + E_t\beta_{t+1}(1-\theta_t^x q(\theta_t^x)(1-\rho_{t+1}^x))U_{t+1}^x. \end{aligned} \tag{22}$$

Unemployed worker receive the unemployment benefit b^x, the discounted continuation value of being unemployed and if he is matched he receives the value of future employment. Inserting these value functions into the Nash bargaining solution yields the individual real wage

$$w_t^x(a_t^x) = \eta(\varphi_t A_t^x a_t^x + c^x\theta_t^x) + (1-\eta)b^x. \tag{23}$$

[5]Due to a free entry condition the equilibrium value of V_t is zero.

The gap between the real wage and the reservation wage is increasing in every time-depending component and the worker's bargaining power.
The firm will endogenously separate from a worker if and only if

$$J_t^x(a_t^x) < 0, \tag{24}$$

i.e. if the asset value of the worker for the firm is below zero. Using this condition and the expressions for the real wages and the vacancy posting condition in equilibrium yields the productivity threshold

$$\tilde{a}_t^x = \frac{1}{(1-\eta)\varphi_t A_t^x}\left[(1-\eta)b^x + \eta c^x \theta_t^x - \frac{c^x}{q(\theta_t^x)}\right]. \tag{25}$$

3.5. Equilibrium

The monetary authority targets the nominal interest rate by following a standard Taylor rule, given by

$$\left(\frac{R_t}{\bar{R}}\right) = \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi}\left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y}, \tag{26}$$

where ϕ_π and ϕ_y are the respective weights. The aggregate productivity shock is formulated as

$$A_t = A_{t-1}^{\rho_A} e^{\alpha_{A,t}}. \tag{27}$$

The sector-specific shocks also follow a standard AR(1), i.e.

$$A_t^x = {A_{t-1}^x}^{\rho_{A^x}} e^{\alpha_{A^x,t}}. \tag{28}$$

The i.i.d. error terms are $\alpha_{A^x,t} \sim N(0,\sigma_x)$ with $cov(A_{t-1}^x, \alpha_{x,t}) = 0 \ \forall \ t$.
The resource constraint is given by

$$Y_t = C_t + c^m v_{it}^m + c^s v_{it}^s. \tag{29}$$

In order to quantify worker flows, we determine the job creation and destruction rates. The job creation rate is given by

$$jcr_t^x = \frac{(1-\rho_t^x) v_{t-1}^x q(\theta_{t-1}^x)}{n_{t-1}^x}, \tag{30}$$

and the job destruction rate is - in the absence of exogenous separations - simply given by

$$jdr_t^x = \rho_t^x. \tag{31}$$

Then, for given initial conditions, a determined equilibrium exists that satisfies the system of equations containing (3) to (10), (16), (17), (23), (25) to (31), and the expressions for the labor market tightness and the separation rate. This system is log-linearized around its deterministic steady state and simulated using Dynare.

3.6. Calibration

We calibrate the model on a quarterly basis for the U.S.. Parameters are calibrated according to the recent literature and empirical evidence. The discount factor β is set to 0.99, as usual in the literature. The risk aversion parameter σ is calibrated to be 2. The demand elasticity is set to 11 based on the calibration of Christoffel et al. (2009). α in the production function is set to 0.75. The mean of the distribution functions is set to 0, while the dispersion is 0.12. Steady state unemployment rates are set to $n^s = 0.7$ and $n^m = 0.9$ (see e.g. Albrecht et al. (2006) for differences in the unemployment rates of hig- and low-skilled workers), to account for the shortcoming of the unemployment rate namely the nonconformity of effective searchers and unemployed workers as stressed by Cole and Rogerson (1999). Furthermore, we assume symmetric bargaining and set $\eta = 0.5$. According to Lubik (2009), we set the elasticity of the matching function to 0.74. We impose the following sector-specific steady state separation rates, $\rho^m = \rho^s = 0.08$. The job filling rate is set to 0.7, as in den Haan et al. (2000). Finally, the Rotemberg (1982) price adjustment cost parameter ψ is set to 40, in line with Krause and Lubik (2007). The autocorrelations of the three shocks are all set to 0.9. For the sticky price version we apply the standard Taylor rule parameters, i.e. $\phi_\pi = 1.5$ and $\phi_y = 0.125$. Missing parameter values are computed from the steady state.

4. Discussion

In this section, we discuss the response of our economy to an aggregate and sectoral shocks. We begin by discussing the dynamics in the RBC core of our model and then we address the importance of sticky prices..

4.1. The Flexible Price Economy

We begin our analysis with the consideration of an one percent shock to manufacturing productivity within the RBC core. The response of our economy is presented in Figure 1. We observe a sectoral shift towards manufacturing workers. Unemployment in the manufacturing sector decreases, while it increases in the service sector. The intuition for this is that in the shock sector workers become more productive such that the firm increases its demand for those workers while decreasing the demand for workers in the other sector whose productivity stays constant. Unfortunately, and as common in endogenous separation models, the main adjustment process works along the exit margin of the firm.[6] The firm increases employment by slightly increasing vacancies in the manufacturing sector and by mainly reducing job destruction. The opposite pattern is visible in the service sector. As productivity increases, real wages increase in the manufacturing sector. In addition, we find that real wages increase in the service sector as well. The reason is a selection process in the service sector, which leads to lay-offs of less productive workers. Aggregate effects are relatively small. We obtain large shifts in the composition in output, while aggregate output stays rather constant over the cycle which supports Lucas (1977) view of average out. Aggregate unemployment increases, since the increase in service-unemployment is larger than the decrease in unemployment in the manufacturing sector. The response of aggregate vacancies is quite small, since the sector-specific responses off-set each other. We find that the shock creates an aggregate Beveridge curve. But, due to the average out, standard deviations are not in line with evidence.

Now, we consider a shock to service productivity. As before, unemployment decreases in the shock sector while it increases in the other sector (see Figure 2). Firms adjust mainly along the separation margin. In contrast to the manufacturing shock, aggregate unemployment decreases in this case since the effects in the service sector dominate. Real wages in both sectors decrease. For the manufacturing sector this result is driven by the decrease in labor market tightness, implying that re-hiring costs are smaller. In the service sector the decrease of the threshold - in order to increase sectoral employment - leads wages to decrease, since also less productive workers stay within the firm. As we have seen, the reaction of aggregate output is rather small, due to large reallocation effects. As in the previous case, the shock creates and aggregate Beveridge curve but is not able to replicate the standard deviations due to average out.

[6] The hiring of workers is costly and time consuming, whereas firing is costless and directly affecting the evolution of employment.

Finally, we briefly analyze the aggregate shock to our economy. This shocks affects the sectors in a similar way and leads to effects working in the same direction.

4.2. The Sticky Price Economy

As we have discussed the underlying mechanisms at work in the precedent section, we now want to focus on the ability of the model to replicate the stylized facts. Therefore, we introduce sticky prices in order to bring the model closer to reality.
As before, we start with the shock in the manufacturing sector. From Table 1, we infer that the model is able to create a quite strong aggregate Beveridge curve, i.e. $corr(u, v) = -0.90$. However, we do not observe sectoral Beveridge curves as found in the data. In terms of standard deviations, the model creates too much volatility - in relation to aggregate output - of sectoral unemployment and vacancies. The standard deviation of labor market tightness in the manufacturing is too small compared to its empirical value, while service sector tightness fits quite well. Compared to the one-sector endogenous separation model (here we use Krause and Lubik (2007) as a reference point), we find that our model creates more volatility. In detail, standard deviations of aggregate vacancies and tightness are much closer to their empirical values. The volatility of aggregate unemployment remains unchanged.
Furthermore, and in response to the service shock, the model is able to replicate the empirical volatility of aggregate unemployment and is much closer in generating the value of tightness. Aggregate vacancies are as volatile as in the one-sector reference model. We find that the model is able to explain the volatilities in the manufacturing sector reasonably well, while it creates too much volatility in the service sector. In addition, the model is not able to replicate an aggregate or sectoral Beveridge curves. The increase in vacancy posting in the manufacturing sector is too small in relation to the drop of vacancy posting in the service sector.
Next, we consider a joint shock hiting both sectors. We find that the dynamics are driven by the manufacturing sector shock. Therefore, we do find a quite strong aggregate Beveridge curve and a small decrease of volatility in the entire economy. The fact that the service sector shock in the sticky price version does not create the Beveridge curve - as in the RBC core - is caused by the stronger effect of output in the sticky price model implying stronger substitution effects towards the service sector. This causes vacancies to decrease in the manufacturing sector and, in aggregate, vacancies decrease, breaking the negative correlation of unemployment and vacancies.
Finally, we consider the aggregate productivity shock. We find that the model creates

much more volatility of aggregate unemployment and vacancies. In fact, replicates these facts reasonably well. However, the improvement for aggregate labor market tightness is quite small. The aggregate shock creates too much volatility in both sectors. The exception is service labor market tightness, while the volaility of labor market tightness in the manufacturing sector is again too low.

In general, we can draw the conclusion that the manufacturing sector shock seems to dominate in the data. It is also much likely that aggregate and manufacturing shocks jointly drive the economy.

5. Final Remarks

This papered analyzed whether the introduction of a two-sector production process into an endogenous separation matching model can generate the observed volatility and cyclicality of key labor market variables. We know that the standard endogenous separation matching model has shortcoming in explaining those facts jointly. In order to overcome this shortcoming, we propose a solution going back to the sectoral shift literature from Lilien (1982). In our model, output is produced with a combination of two inputs coming from the manufacturing and the service sector. We have shown that the productivity shock hiting the manufacturing sector is able to replicate an aggregate Beveridge curve and increases the volatility of key variables. However, it creates too much volatility of sectoral variables. Our analysis shows that sectoral shocks in a sticky price environment do not average out and create aggregate fluctuations due to imperfect labor markets and the induced nominal rigidity. Compared to an one-sector model, e.g. Krause and Lubik (2007), our model creates much more volatility in response to an aggregate productivity shock, but fails to generate the Beveridge curve. We can draw the conclusion that a combination of the manufacturing sectoral and the aggregate shock replicates the empirical volatilities and correlations reasonably well.

Along a different dimension, the RBC model is able to generate the Beveridge curve for both sectoral shocks. However, it completely fails to generate the empirical volatility values due to average out effects. Sticky prices, because they break the average out, increase the ability of the model to replicate volatilities but rather work against the Beveridge curve relation.

A. References

Abraham, Katharine G. and Lawrence F. Katz. 1986. "Cyclical Unemployment: Sectoral Shifts or Aggregate Disturbances?" *Journal of Political Economy*, Vol. 94(3): 507-522.

Albrecht, James, Lucas Navarro, and Susan Vroman. 2006. "The Effects of Labor Market Policies in an Economy with an Informal Sector." IZA Discussion Paper, No. 2141.

Balleer, Almut. 2009. "New Evidence, Old Puzzles: Technology Shocks and Labor Market Fluctuations." Kiel Working Paper, No. 1500.

Barnichon, Regis. 2009. "Vacancy posting, Job Separation and Unemployment Fluctuations." Mimeo.

Christoffel, Kai, Keith Kuester, and Tobias Linzert. 2009. "The role of labor markets for euro area monetary policy." *European Economic Review*, Vol. 53(8): 908-936.

Cole, Harold L. and Richard Rogerson. 1999. "Can the Mortensen-Pissarides Model Match the Business Cycle Facts?" *International Economic Review*, Vol. 40(4): 933-960.

Davis, Steven J.. 2001. "The Quality Distribution of Jobs and the Structure of Wages in Search Equilibrium." NBER Working Paper, No. 8434.

Davis, Steven J. and John C. Haltiwanger. 2001. "Sectoral job creation and destruction responses to oil price changes." *Journal of Monetary Economics*, Vol. 48(3): 465-512.

Davis, Steven J., R. Jason Faberman, and John C. Haltiwanger. 2007. "The Establishment-Level Behavior of Vacancies and Hiring." Mimeo.

Fujita, Shigeru, Nekada, Christopher J. and Ramey, Garey. 2007. "The Cyclicality of Worker Flows: New Evidence from the SIPP." Federal Reserve Bank of Philadelphia Working Paper, No. 07-5.

Fujita, Shigeru and Ramey, Garey. 2007. "Reassessing the Shimer Facts." Federal Reserve Bank of Philadelphia Working Paper, No. 07-2.

Fujita, Shigeru and Ramey, Garey. 2008. "The Cyclicality of Separation and Job Finding Rates." Federal Reserve Bank of Philadelphia Working Paper, No. 07-19.

den Haan, Wouter J., Garey Ramey, and Joel Watson. 2000. "Job Destruction and the Propagation of Shocks." *American Economic Review*, Vol. 90(3): 482-498.

Hagedorn, Marcus and Iourii Manovskii. 2008. "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited." *American Economic Review*, Vol. 98(1): 692-706.

Hamilton, James D.. 1988. "A Neoclassical Model of Unemployment and the Business Cycle." *Journal of Political Economy*, Vol. 96(3): 593-617.

Krause, Michael U., and Thomas A. Lubik. 2007. "The (Ir)relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions." *Journal of Monetary Economics*, Vol. 54(3): 706-727.

Lamo, Ana, Julián Messina, and Etienne Wasmer. 2006. "Are specific skills an obstacle to labor market adjustment? Theory and an application to the EU enlargement." European Central Bank Working Paper, No. 585.

Lilien, David M.. 1982. "Sectoral Shifts and Cyclical Unemployment." *Journal of Political Economy*, Vol. 90(4): 777-793.

Lubik, Thomas A.. 2009. "Estimating a Search and Matching Model of the Aggregate Labor Market." Economic Quarterly, Vol. 95: 101-120.

Lucas, Robert E.. 1977. "Understanding Business Cycles." K. Brunner and A. Meltzer (eds.), Carnegie Rochester Series on Public Policy. 5: 7-29.

Lucas, Robert E. and Edward C. Prescott, 1974. "Equilibrium Search and Unemployment." *Journal of Economic Theory*, Vol. 7: 188-209.

Merz, Monika. 1995. "Search in the Labor Market and the Real Business Cycle." *Journal of Monetary Economics*, Vol. 36(2): 269-300.

Mortensen, Dale T. and Nagypál, Éva. 2007. "Labor-market Volatility in Matching Models with Endogenous Separations." *Scandinavian Journal of Economics*, Vol. 109(4): 645-665.

Mortensen, Dale, and Christopher Pissarides. 1994. "Job Creation and Job Destruction in the Theory of Unemployment." *Review of Economic Studies*, Vol. 61(3): 397-415.

Ramey, Garey. 2008. "Exogenous vs. Endogenous Separation." Mimeo.

Rotemberg, Julio. 1982. "Monopolistic Price Adjustment and Aggregate Output." *Review of Economic Studies*, Vol. 49(4): 517-531.

Shimer, Robert. 2005. "The Cyclical Behavior of Equilibrium Unemployment and Vacancies." *American Economic Review*, Vol. 95(1): 25-49.

Tapp, Stephen. 2007. "The Dynamics of Sectoral Labor Adjustment." Queens Economics Department Working Paper, No. 1141.

B. Tables and Figures

Table 1: Business Cycle Statistics - Sticky Price Version

	Data	KL	A^m	A^s	A^m&A^s	A
Standard Deviations						
u^{agg}	6.90	4.36	4.32	7.51	4.58	11.67
u^m	4.50	-	19.47	4.83	18.90	10.81
u^s	2.50	-	12.20	11.26	12.14	12.51
v^{agg}	8.27	1.34	3.95	1.34	3.85	6.82
v^m	3.50	-	11.65	3.46	11.32	8.17
v^s	1.50	-	7.27	6.32	7.22	7.32
θ^{agg}	14.96	4.19	8.06	6.20	7.96	4.99
θ^m	15.50	-	7.94	1.73	7.70	2.68
θ^s	6.50	-	6.54	6.16	6.51	6.16
Correlations						
u^{agg}, v^{agg}	-0.95	0.28	-0.90	0.99	-0.78	0.99
u^m, v^m	-0.92	-	0.99	0.97	0.99	0.99
u^s, v^s	-0.75	-	0.90	0.91	0.90	0.94

Notes: Data values for the aggregate variables are taken from Krause and Lubik (2007). Standard deviations are theoretical moments relative to (aggregate) output.

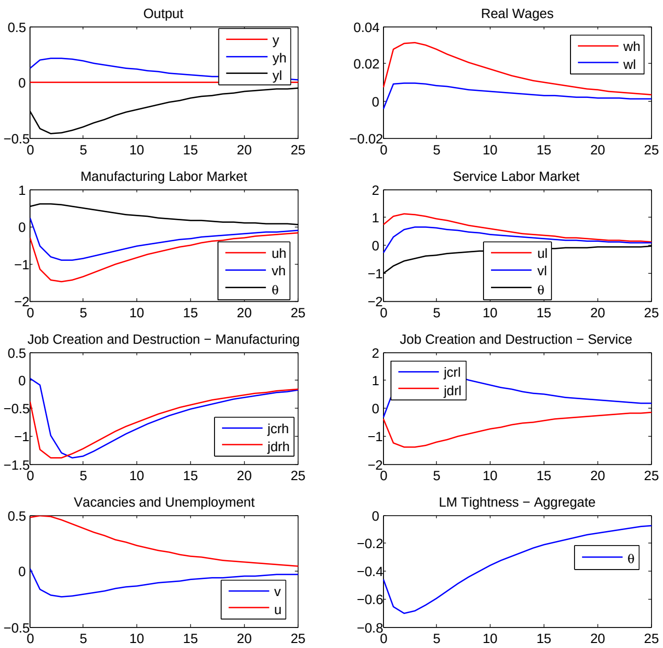

Figure 1: Productivity Shock, RBC Model, Manufacturing

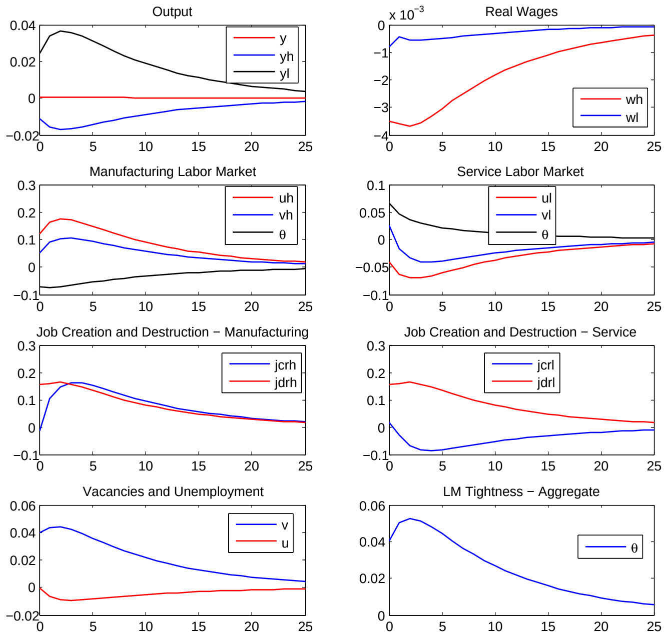

Figure 2: Productivity Shock, RBC Model, Service

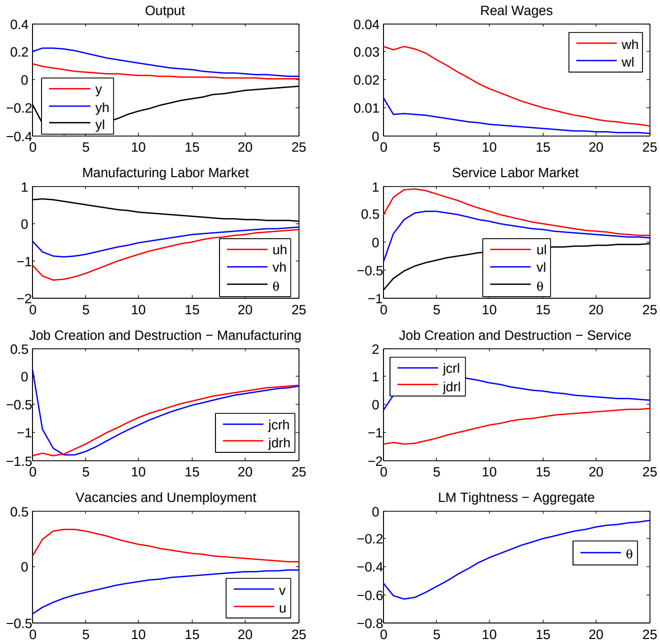

Figure 3: Productivity Shock, Sticky Price Model, Manufacturing

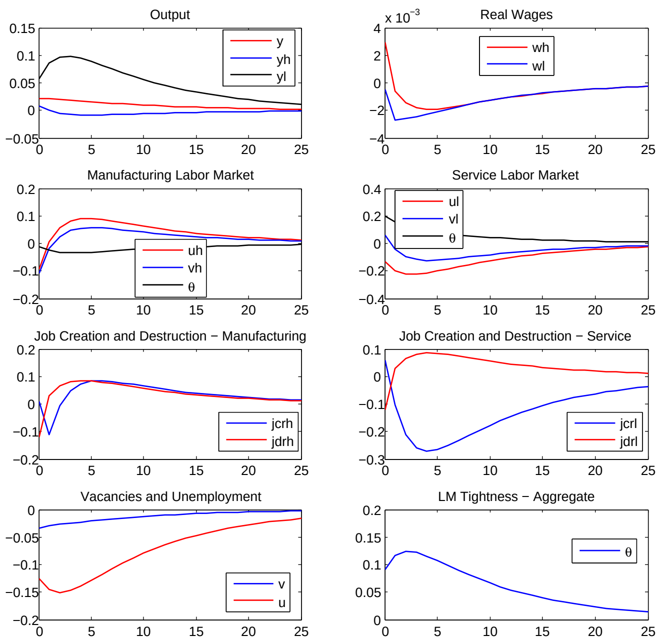

Figure 4: Productivity Shock, Sticky Price Model, Service