The 2010 Nobel Prize in Economics: How the DMP Model Explains Current High Unemployment

Robert E. Hall
Hoover Institution and Department of Economics,
Stanford University
National Bureau of Economic Research
rehall@stanford.edu; website: Google "Bob Hall"

January 11, 2012

Stockholm's recognition of the combined contributions of Peter Diamond, Dale Mortensen, and Christopher Pissarides brought immense pleasure and satisfaction to the macro-labor research community. The DMP model honored by the prize is a central component of modern macroeconomics.

Given the current high unemployment rates in most advanced economies, it seems natural to focus my remarks about the DMP model on how the model explains current high unemployment. I'll start with a simple exposition of the model. The contributions of the three creators of the model are so intertwined that I will avoid the attempt to describe which member of the team created any individual element of the model. Focusing on the current applications of DMP is the best way to make the point that this line of research, dating back to the late 1960s, is still current and vital and making even more progress.

The DMP model of unemployment is widely accepted as the most realistic account of unemployment based on a careful and full statement of the underlying economic principles governing labor turnover, job-finding rates, and wage determination. Its building blocks are (1) a stochastic model of labor turnover, where workers separate from jobs, become unemployed, and find new jobs, (2) a model of labor-market tightness, with employers choosing job creation volumes and exerting recruiting effort that controls the job-finding rate, in response to the payoff to job creation, and (3) a bargaining model of wage determination, which sets the incentive to create jobs because employers capture the difference between workers' productivity and their wages.

The stochastic model of labor turnover is the oldest and most familiar part of the model. Workers separate from jobs at a rate that is somewhat cyclical—in particular, the separation rate rises during sharp contractions such as the one that occurred in the U.S. at the end of 2008. But it is a reasonable simplification, especially in studying long periods of stable high but not rising unemployment, to take the separation rate as a constant. Unemployed workers find jobs at a rate that is highly cyclical. It is vastly harder and more time-consuming to find jobs in today's labor market with 8.6 percent unemployment than in a market with normal unemployment between 5 and 6 percent. Except in times of rapid change in unemployment, the unemployment rate is the ratio of the separation rate to the sum of the separation rate and the job-finding rate.

The model of labor-market tightness is a revolutionary element of the DMP framework. Prior to its development, economists were aware that markets could be tight or slack but lacked models that made tightness a coherent concept. The measure of tightness is the ratio of vacancies to unemployment. In a tight market, employers find it hard and time-consuming to recruit new workers, so vacancies are high. The unemployed find it easy and quick to find jobs, so unemployment is low. Note that both of these propositions presume that flows through the labor market—controlled by separations—are roughly constant, as I noted earlier. Two key functions of the model depend on tightness (and only on tightness). These are the job-filling rate—the daily probability that a vacancy will find a new worker—and the job-finding rate—the daily probability that a searcher will find a job. The job-filling rate falls with increasing tightness and the job-finding rate rises.

So far, I've talked about the mechanics of the DMP model. The first of two key pieces of economics in the model explains how tightness responds to job-creation incentives. The DMP model in its simplest form—as in Mortensen and Pissarides (1994) or Shimer (2005)—embodies a strong asymmetry with respect to incentives. Employers make a resource allocation decision, namely the volume of vacancies to create and corresponding volume of recruiting effort to expend. Job-seekers make no corresponding decision about search effort.

Of course, extensions of the model to endogenous search effort have appeared, but I will stick with the asymmetric case, which captures the essence.

Let W be the present value of the wage that a worker will be paid over the course of a job and let P be the present value of the worker's contribution to future revenue (the marginal revenue product of labor). Then $P - W$ is the value that hiring a new worker adds to the firm at the moment of the hire, excluding the costs expended earlier to recruit the worker. The choice that a firm makes is whether to pay the cost of holding a vacancy open for a day, at cost k. The expected payoff is the job-filling rate times the benefit of a hire: $q(\theta)(P-W)$. In equilibrium, the cost and payoff must be the same, given free entry to vacancy creation, a key assumption of the model. The first of the two central equations of the DMP model is the *zero-profit condition*,

$$q(\theta)(P - W) = k. \tag{1}$$

The third and by far most challenging piece of the DMP model is the model of wage determination. In the canonical DMP model, the worker and employer split the surplus of their match according to the Nash bargain. With the present value of the worker's reservation value denoted as R and the worker's share as β, the surplus is $P - R$ and the Nash-bargain wage is

$$W = R + \beta(P - R) = \beta P + (1 - \beta)R. \tag{2}$$

In a setting where an outside option fixes R, the DMP model is really easy to explain and manipulate. Given P and R, the Nash bargain determines the wage W according to equation (2) and then $P - W$ determines the tightness of the labor market (and thus the unemployment rate) according to equation (1). But in a realistic labor-market setting, R is not set outside the market, but rather depends on conditions in the market. When engaging in a Nash bargain in the labor market where the worker has a comparative advantage, the threat point of the worker is usually to continue searching in that market, not retreat to an alternative outside that market. So the value of R depends on what wage the worker expects to earn in the job that will be found after a period of search, how long it will take to find that job, and what unemployment benefits the worker receives and what value the worker attributes to not having to work while searching. Although the DMP model has a neat answer to that problem, a luncheon talk is not the place to present it.

An influential paper first circulated a decade ago, Shimer (2005), studied the wage determination problem in a setting carefully guided by the relevant data on turnover. He treated P, the marginal revenue product of labor, as the exogenous driving force, and solved equation (1), equation (2), and the unstated equations for determining the reservation value R (he was writing for the *American Economic Review*, not giving a luncheon talk, but even so he put the guts of the derivation in an appendix). He reached an important and surprising conclusion—when P changes, R changes by almost exactly the same amount and so does W! The employer payoff $P - W$ hardly changes at all, so tightness remains essentially the same as does unemployment. This finding became the Shimer Puzzle. Addressing the puzzle occupied a big chunk of the research effort of the macro-labor research community for the rest of the decade. Rogerson and Shimer (2010) surveys these efforts.

Shimer's finding did nothing to diminish the hold of the DMP model on economists interested in understanding how unemployment arises in a full equilibrium and what makes it change over time. It did cast some doubt on the assumption that the wage bargain follows Nash and some doubt on Shimer's choices of parameter values. Mainly it stimulated a huge amount of new work in the DMP framework. The central ideas of DMP still dominate thinking about unemployment from a macro perspective. To continue my commentary and reach the topic of today's high unemployment, I drop the Nash assumption and replace equation (2) with a more general setup,

$$W = B(P, \theta, x). \tag{3}$$

Here x is some variable not previously considered that influences the job value. The function B describes some bargaining protocol that makes W less responsive to the marginal revenue product P or to tightness θ and may depend on a new variable x that can keep wages high and thus raise unemployment. Here wage stickiness comes into the story. Because $P - W$ controls labor-market tightness through equation (1), any factor that reduces the response of W to P makes unemployment rise more in response to a given decline in P. Further, if wages are less responsive to tightness θ, tightness is less able to cushion against the effects of changes in P or the new variable x.

It's critically important to stress that making wage determination less sensitive to some variables is *not* recrudescence to the primitive pre-DMP idea that unemployment is just a gap between labor supply and labor demand resulting from a non-equilibrium wage. The model continues to describe a full economic equilibrium, where no pair of actors can improve their joint position.

The crowd of researchers attacking the Shimer Puzzle took the problem to be raising the response of tightness to labor productivity, taken as a proxy for the marginal revenue product of labor, P. Making the wage somewhat less responsive to productivity turned out to accomplish that goal nicely, as Shimer pointed out before the publication of Shimer (2005). But this solution to the puzzle has proven unsatisfactory because the long period of high unemployment starting toward the end of 2007 did not coincide with a similar movement of productivity. Rather, productivity fell sharply early in the slump but then recovered fully, even while unemployment remained close to 10 percent. And in the recessions of 1990 and 2001, productivity hardly fell at all, despite substantial increases in unemployment. Falling productivity cannot be the whole story of why unemployment rises sharply in recessions.

Now let me turn to the possible role of new influences on the wage, the x in equation (3). Many new variables come to mind. For example, unemployment benefits raise the value of the worker's outside option in the wage bargain—a feature of the DMP model from its beginnings. A dramatic increase in benefits could raise unemployment. Recent research pursuing that idea has confirmed the increase, but suggests it is small.

I'll spend the rest of my time on the idea that the new variable is related to inflation. This idea is particularly appropriate for discussion here because Dale's first published paper and first contribution to unemployment analysis dealt with the Phillips curve, the relation between inflation and unemployment. The DMP literature—with a couple of exceptions I will feature—has not paid much attention to this issue recently, but it may become more important in the near future, as the DMP research community struggles to understand continuing high unemployment.

I believe that Walsh (2003) was the first paper to develop a version of the DMP model where a decline in inflation raised unemployment. The paper has New Keynesian sticky prices. As Rotemberg and Woodford (1999) observed, the way that New Keynesian models generate a Phillips curve is that diminished inflation lowers cost immediately but with sticky prices, the corresponding fall in prices is delayed. The price/cost ratio, a measure of market power, rises. The marginal revenue product of labor shifts inward when market power rises. The DMP model generates higher unemployment with a lower marginal revenue product according to the same principles that result in higher unemployment when productivity falls. Walsh adopts the Nash wage bargain of the canonical DMP model, which implies that his model may generate low unemployment responses for the reason that Shimer pointed out. Though Walsh's model was the pioneer in bringing inflation into the DMP model, his approach has not been adopted more widely in the decade since the publication of his paper. See Nekarda and Ramey (2010) for negative empirical evidence on the cyclical behavior of margins.

Gertler, Sala and Trigari (2008) (GST) inject inflation into DMP wage determination in quite a different way. They consider a nominal version of an earlier model, Gertler and Trigari (2009). That model overcomes the Shimer Puzzle by replacing Nash bargaining at the time of hire with a form of wage stickiness. A Poisson event controls firm-level wage bargaining, which takes the Nash form. Between bargaining times, the wage of newly hired workers adheres to the most recent bargain. If labor demand turns out to be higher than expected at bargaining time, the part of the surplus captured by the employer rises and the incentive to recruit workers rises. By standard DMP principles, the labor market tightens and unemployment falls. Building on that setup, GST consider a wage bargain made in nominal terms, which has the effect of making the real wage sensitive to the rate of inflation. Workers hired between bargaining times inherit their nominal wages from the most recent bargain. As a result, at the time of hire, the real wage is lower to the extent of the amount of inflation cumulated since the last bargain.

The GST model assumes that the wage bargain is made in money terms, as the traditional Keynesian literature likes to say. The substance of the assumption is that a state variable— the most recently bargained nominal wage— influences the job value for new hires until the next bargain occurs. This assumption has had a behavioral tinge in that literature—the role of the stale nominal wage arises from stubbornness of workers or employers or from money illusion. From the perspective of bargaining theory, however, as long as the stale wage keeps the job value in the bargaining set, that wage is an eligible bargain. There's no departure from strict rationality in the GST model.

The GST version of the DMP model can explain high unemployment in today's economy. With lower inflation as a result of the slack conditions that have prevailed since 2007, real wages paid to new hires are elevated. The payoff from hiring new works is correspondingly lower. It takes a higher job-filling rate to justify new hires and satisfy the zero profit condition of equation (1). The job-finding rate is lower and unemployment is higher.

I've done some investigation of the realism of this proposition, summarized in Figure 1. In December 2007, the unemployment rate was 5.0 percent and the rate of inflation was

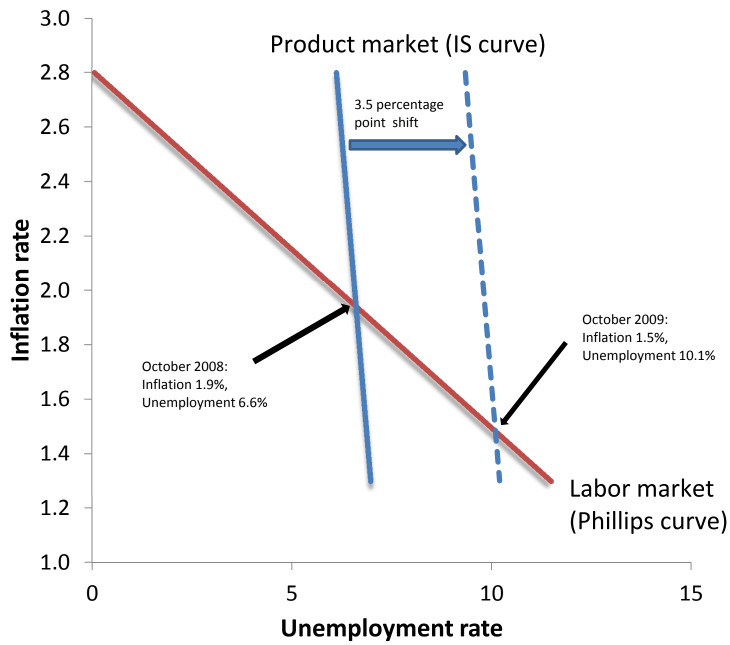

Figure 1: The U.S. Economy in December 2007 and December 2009

2.4 percent, measured by the average one-year-ahead forecast for the Consumer Price Index in the Survey of Professional Forecasters (other measures of inflation are quite similar). In December 2009, inflation was 0.8 percentage points lower at 1.6 percent and unemployment was 4.9 percentage points higher. The figure shows the Phillips curve implied by the data. It is in reasonable agreement with Phillips curves from the GST and other models.

Figure 1 make the reasonable assumption that no shift occurred in the labor-market curve—the impetus for the contraction came entirely from the adverse developments in the product market. These include the consumption decline resulting from household deleveraging, the collapse of homebuilding, and the cutback in producer and consumer durables purchases resulting from the increase in financial frictions from the crisis.

The product-market or IS curve shown in the figure would normally be written in terms of the real interest rate. For the period considered here, however, the nominal interest rate remained at essentially zero at all times. Hence the real rate was minus the rate of inflation. So instead of a downward-sloping IS curve with a real interest rate on the vertical axis, the figure has an upward-sloping curve with the rate of inflation on the vertical axis.

From the GST impulse response functions, I calculate the slope of the product-market curve to be 1.8 percentage points of unemployment per percentage point increase in the real interest rate, or, in terms of the figure, with a nominal rate pinned at zero, 1.8 percentage points of unemployment per percentage point decrease in the rate of inflation. The figure shows the 2007 product-market curve as the solid line with this slope passing through the observed inflation-unemployment point. It shows the 2009 product-market curve as the dashed line with the same slope passing through the 2009 inflation-unemployment point.

I conclude that adding inflation as an element of wage determination, as in GST, is capable of explaining high unemployment in times of inflation slowdowns. The DMP model can explain high unemployment.

Dale has another idea about how the DMP model can generate lingering high unemployment, but I'll let him talk about it.

References

Gertler, Mark and Antonella Trigari, "Unemployment Fluctuations with Staggered Nash Wage Bargaining," *The Journal of Political Economy*, 2009, *117* (1), pp. 38–86.

____, Luca Sala, and Antonella Trigari, "An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining," *Journal of Money, Credit and Banking*, 2008, *40* (8), 1713–1764.

Mortensen, Dale T. and Christopher Pissarides, "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, 1994, *61* (0), 397–415.

Nekarda, Christopher J. and Valerie A. Ramey, "The Cyclical Behavior of the Price-Cost Markup," June 2010. University of California, San Diego.

Rogerson, Richard and Robert Shimer, "Search in Macroeconomic Models of the Labor Market," in Orley Ashenfelter and David Card, eds., *Handbook of Labor Economics, Volume 4A*, Elsevier, 2010, pp. 619–700.

Rotemberg, Julio J. and Michael Woodford, "The Cyclical Behavior of Prices and Costs," in John B. Taylor and Michael Woodford, eds., *Handbook of Macroeconomics*, Vol. 1B, Amsterdam: Elsevier, 1999, chapter 16, pp. 1051–1135.

Shimer, Robert, "The Cyclical Behavior of Equilibrium Unemployment and Vacancies," *American Economic Review*, 2005, *95* (1), 24–49.

Walsh, Carl E., "Labor Market Search and Monetary Shocks," in S. Altug, J. Chadha, and C. Nolan, eds., *Elements of Dynamic Macroeconomic Analysis*, Cambridge University Press, 2003, p. 451486.