EMPLOYMENT AND PRICES IN A SIMPLE MACRO-ECONOMY

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Abstract: This exercise sets up inter-linked labor and goods markets in a classroom macro-economy. Students with worker roles are endowed with labor that can be consumed or sold to firms, who post wages, purchase labor, and produce goods that can either be consumed or sold to workers. The money from sales is used by firms to purchase labor in the next period. Complicated record keeping is avoided by using ordinary playing cards to represent money and goods. The exercise can stimulate a discussion on potential output, unemployment, and the role of money in determining wages and prices.

Keywords: unemployment, macroeconomics, experimental economics, classroom experiments.

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I. Introduction

The standard macroeconomic models used in undergraduate courses (Keynesian cross, ISLM) are presented at a high level of aggregation that is a common source of complaint. But attempts to build in micro-foundations, e.g. overlapping generations or infinite-lived representative agents, require a level of mathematical analysis that is beyond the abilities and interests of most economics majors. The upshot of this is that intermediate macroeconomics courses are often unpopular with both students and faculty, in comparison to more institutionally based courses like Finance or Money and Banking. This paper presents a simple classroom experiment in which the students themselves are the optimizing agents, and the outcomes can be related to standard macroeconomic issues of full employment, price determination, etc.

The exercise is appropriate for classes or discussion sections that range in size from 6 to 40 students, and it can be completed, with discussion, in about an hour. Depending on the level of discussion, the exercise can be used in conjunction with introductory and intermediate macroeconomics courses. The procedures are described in more detail in Section II, and some suggestions for structuring the class discussion are provided in Section III. The final section contains a guide to some of the related literature in classroom games and experimental economics.

II. Procedures

The basic idea is to set up a closed economy with production, exchange, and fiat money. Students are given the role as either a worker or a firm. There are exactly twice as many workers as firms, to facilitate the calculation of optimal allocations, as explained below. Workers are endowed with leisure each period, which they can consume or sell to firms, who use the labor to produce goods, which in turn are either consumed by that firm or sold to workers. Firms need to acquire labor before producing output, so the labor market opens before the goods market. The money that workers receive as wages is then used to purchase goods, as depicted in a standard circular flow chart.

The economy is quite simple, but record keeping can become complicated, and therefore, we use playing cards to keep track of money and goods. The red cards (Hearts or Diamonds) are units of currency, and the black cards (Clubs or Spades) represent units of real goods and services. In particular, each firm starts off the first period with 26 red cards that can be used to purchase labor from workers (so you need one deck of cards per firm). Workers are endowed with three black cards in each period, which they can either consume or sell in exchange for fiat money.

After workers sell some or all of their black cards, there is a phase in which workers consume their remaining time as leisure, and firms engage in production. First, consider the production and its effect on the demand for labor. The marginal product of each of the first two units of labor input is 6, the marginal product of the 3rd and 4th units of labor is 3, and the marginal product of additional units of labor input is 1. This production is implemented: the first black card purchased by a firm becomes 6 black cards (we add 5 to the original), the second

black card purchased also becomes 6 black cards. If a third black card is purchased, we add 2 black cards, and similarly for the 4th black card purchased.[1] Nothing is added to the fifth and higher numbers of black cards, so the marginal product of these input units is 1. This marginal product schedule for a firm is shown as the dark line in Figure 1.[2] In a static setting, a firm will demand a unit of labor if its marginal product exceeds the real wage, so the marginal product schedule represents the firm's demand for labor, with real wage on the vertical axis. (This analysis will be modified slightly when we introduce a dynamic element associated with the probability of stopping the experiment.)

Next consider the supply of labor. There is a diminishing marginal value of leisure, which is implemented as follows. If a worker sells two black cards and keeps only one, then the one card kept is tripled, i.e. we add two black cards to the one kept. If the worker keeps two black cards, the first card is tripled but the second card is only doubled. Finally, the third black card kept is left unchanged. Thus the marginal value of leisure is 3 for the first unit, 2 for the second unit, and 1 for the third unit. The supply of labor is obtained by taking these units in reverse order: the first black card sold by the worker has an opportunity cost of 1 (black card), the second an opportunity cost of 2, and the third has an opportunity cost of 3. Since there are two workers per firm, we have plotted the supply function of two workers combined in Figure 1. At a real wage of 1.5, for example, each worker would only be willing to sell one unit, since the second unit has a leisure value of 2. Notice that the supply function overlaps the firm's labor demand function at a quantity of 4 labor units, which is the efficient level of employment (2 per worker).

At the efficient level of employment, each firm produces 18 black cards (6+6+3+3), and

each worker consumes 3 black cards, which is the leisure value of the endowment unit that is not sold. So at the end of the period, the total consumption of black cards by each one-firm/two-worker group would be $18 + 3 + 3 = 24$, if the efficient outcome in Figure 1 is reached. Whether or not the resulting outcome is efficient depends on what happens in the labor and goods markets, which we describe next.

The labor market begins when firms decide on wage offers, i.e. the number of red cards they are willing to trade for a black card. Once all firms have written their wage offers on their decision sheets, post them on the blackboard next to the firm's desk. Then use a random device to determine which worker gets to enter the labor market first.[3] This worker generally goes to the high-wage firm and asks to sell one or more black cards. All transactions must be at the posted wage; no haggling is allowed. The firm may limit the quantity of labor purchased at the posted wage, in which case the worker may approach another firm. When this worker is finished, the next worker in sequence gets to purchase. After several workers have finished, it becomes apparent that some of the firms have stopped buying labor, and the remaining workers have to go the firms with lower wages. The labor market closes when all workers have finished, or when all firms have stopped buying.

Then production and leisure consumption occurs. The instructor can go to the desk of each worker and firm and place additional black cards on top of those already there, as described above. After production, the firms typically have large stocks of black cards. Firms then choose their prices (number of red cards required to purchase a black card), which are recorded on the blackboard after all firms have recorded their decisions on paper. Then a worker is selected at random, as before, to begin making purchases. Firms may limit sales quantity, but all sales must

be at the posted price. The cards are actually exchanged after each transaction, which facilitates record keeping. When the first worker selected has finished purchasing units, the next worker in the numerical sequence gets to purchase. This continues until all workers have made purchases or until all firms have stopped selling.

At the end of the period, workers and firms count up their black cards, which determine their "earnings": each card is worth a dollar. It is possible to pay a percentage of earnings in cash, perhaps to maintain interest and ensure careful thinking, but we have found that this is not necessary with University of Virginia students. After earnings are recorded, you should take away all black cards, except for the three-card endowment for each worker. Red cards stay where they are, so the money supply is fixed.

We typically repeat this procedure for three periods, and then use the throw of a die to determine whether to stop, e.g. the throw of a 6 stops the experiment. Since red cards are worthless at the end of the experiment, this random stopping rule serves as a kind of discount factor, making money today more valuable than the promise to deliver money in the future. In particular, this cost of holding money is borne largely by firms who hold money from sales of goods in order to purchase labor in the next period. Basically this cost shifts the demand for labor down, without affecting the optimal employment in this example, as can be seen by considering the firm's optimal sales decision: a firm that sells a unit of output gets P dollars which can be used to buy W/P units of labor in the next period, at a marginal product denoted by MP. If the probability of termination is less than one, say $1-r$, then the value of this marginal product is only $(1-r)$MP, which should be equated to the real wage, W/P. Thus the marginal product curve in Figure 1 has been shifted down by a factor of $(1 - 1/6) = 5/6$, to obtain the

dashed-line demand for labor curve for a firm.[4] The downward adjustment of the marginal product curve can be skipped in an introductory course.

To summarize the procedures: 1) Decide on the number of firms (from 2 to 5) and the number of workers (from 4 to 10), and copy a set of instructions for each. 2) Separate the red cards and the black cards for a number of decks that equals the number of firms, so that you have a 26 red card endowment for each firm. 3) Seat the firms next to a blackboard and pass out the initial card endowments for firms and workers. 4) Read instructions. 5) Open the labor market with firms choosing wages, which are posted on the blackboard. 6) Choose a worker at random to begin selling labor, and go through workers in sequence. 7) Production and consumption of leisure are implemented by adding black cards to those possessed by firms and workers. 8) Open the goods market by letting firms choose prices, which are posted on the board. 9) Choose a worker at random to begin shopping, and the rest follow in sequence. 10) Workers and firms record final accumulations of black cards (consumption) before these are returned and new black card endowments are given to each worker at the start of the next period.

II. Discussion

It is best to break off for discussion when there is about 15 minutes left in class, even if this means stopping before the randomly determined time.[5] The first topic on everybody's mind is to figure out which people earned the most money, i.e. who has the highest cumulated number of end-of-period black cards. You can begin with several high-earnings workers and ask them to explain their labor supply decisions. These decisions should somehow depend on the wage,

e.g. "the wage of 6 reds per black was good enough for me to want to sell 2 black cards." If you encounter an answer like this, you can ask whether the person would have sold 2 black cards per period if the wage were 6 and the price were 6. Obviously, the second black card should not be sold in this case, since selling one black (labor) card only allows the worker to buy one (commodity) black card back when the wage equals the price. The second black card that a worker sells is worth two black cards if it is consumed, so it should not be sold when the wage equals the price. This naturally leads to a discussion of the real wage, which can be turned to questions of the type: "How many labor units would you sell if wage were 8 and the price were 2, i.e. if the real wage were 4?" These types of questions allow you to construct the labor supply curve for a single worker, or for two workers together, as shown in Figure 1.

A similar line of questioning can determine that the optimal labor purchases by firms should depend, not only on the wage, but also on the price at which goods can be sold. Then questions about optimal purchases for various wage/price combinations can be used to construct the labor demand curve as a function of the real wage. This curve is just the marginal product of labor, as noted above. You will have to explain that you are dealing with two workers and a single firm, since the number of workers is exactly twice the number of firms.[6]

With supply and demand covered, you can ask what the optimal amount of employment should be, i.e. the amount that maximizes the sum of the black cards produced by firms and the black cards created through workers' consumption of leisure. The optimal labor quantity, 4, is determined by the overlap of the supply and demand curves in Figure 1. The actual real wages for a six-period classroom experiment at the University of Virginia are shown in the upper right quadrant of Figure 2, just to the right of the labor supply and demand graph.[7] Real wages are

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generally above the competitive range indicated by the horizontal dashed lines, especially in the final periods. This may explain firms' reluctance to purchase all labor units offered by workers, as discussed below.[8]

The next question should request an explanation of the connection between the prevailing real wage and the optimal (black-card-maximizing) level of employment. If questioned, the students can figure out that each two-worker/one-firm combination can obtain at most 24 black cards. This leads to a discussion of how many black cards were actually earned in each period, and how this compares with the optimum. These observations can be summarized with an efficiency measure, i.e. the percentage of the maximum earnings that are achieved in the market economy.

If employment is below the optimal level, you should ask workers whether they hesitated to sell labor, or whether firms did not want to buy more labor at the posted wages. In our experiment, firms were restricting labor purchases to some extent, perhaps because the real wage was too high. This naturally leads to a discussion of (involuntary) unemployment and how the official statistics are measured. You could ask firms why they did not lower wages or increase prices. The answer is often that the risk of lowering the wage is that workers will go to the other firms.

It is interesting to speculate about the effects of an increase in the money supply. This increase could be accomplished by designating a student as the "government" who has a right to "print" new red cards to buy labor for foreign military adventures for example. This new demand in the labor market should raise money wages, raise employment, reduce production, and then raise prices. Such an intervention may even shock an economy out of a low-employment

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situation.

Firms will not wish to hold onto excess red cards at the end of the period, since the die throw may render these cards worthless. The cost of holding cash in excess of what will be needed to purchase labor in the next period is analogous to an interest rate. In a steady state with no frictions, firms will hold just enough cash to purchase labor needed in the next period, and consumers will hold no cash at the end of the period, since they will be able to obtain the cash they need by selling labor in the next period. In such a frictionless steady state, the value of wage expenditures (the wage W times the labor input per firm, L), will just equal the money supply divided by the number of firms, denoted by M. This equilibrium condition for the parameters of the experiment determines wage as a function of M and L: $W = M/L$.[9] This relationship is graphed in the lower-left quadrant of Figure 2, with the wage being measured downward from the center horizontal axis. With an optimal labor input of 4, the predicted wage is shown by the dashed line in the lower part of Figure 2.[10] The actual sequence of money wages (averaged across firms) for the classroom experiment is shown in the lower-right part of the figure. Notice that the wages are approaching the prediction, but that there is a persistent bias, i.e. $W < M/L$, or equivalently, $WL < M$. This inequality reflects the fact that the actual transaction velocity is less than 1 when cash balances exceed the amount absolutely needed to cover wage payments, perhaps because of precautionary motives and frictions due to mismatches between workers and firms.

An increase in the money supply per firm, M, would shift the curved line in the lower-left quadrant downward, and the money wage rate would increase as a result. With no frictions, money is neutral in this setup. Of course, there are frictions in the classroom economy, and

presumable in larger macroeconomies, and it would be interesting to increase the money supply in order to observe the adjustment patterns.

In conclusion, it is possible to set up a simple, closed economy in the classroom with labor, consumption, and fiat money. There is normally some significant underemployment, i.e. employment below optimal levels. However, the efficiency loss for the economy as a whole may be small, since misallocations at the margin are relatively cost-less compared with the high marginal products of inframarginal labor input units. This simple framework is flexible and can be adapted for additional topics, like the effects of fiscal and monetary policy.

III. Further Reading

We are not aware of any classroom experiments that create a closed macroeconomy. There are, however, a number of related research experiments in which subjects were paid their earnings in cash under controlled conditions. Closest to our setup is that of Hey and di Cagno (1996), in which firms had to purchase labor before producing goods. As predicted by Clower (1965), this two-stage nature of the production process produces significant underemployment, unlike the setup in Lian and Plott (1993) where generally efficient outcomes resulted when the labor and goods markets ran simultaneously. As for the role of money, there are two main approaches. Commodity money is used in the experiments reported in Brown (1996) and Duffy and Ochs (1996). In contrast, fiat money is used in McCabe's (1989) experiment, and its value becomes unstable because of the finite horizon. Evans, Honkapohja, and Marimon (1995) provide an interesting solution to the endpoint valuation of fiat money; it is redeemed as commodities at the price level predicted by a subset of subjects. Our decision to use fiat money

instead of commodity money is based on the importance of realism in classroom exercises. We have also tried price-based redemption schemes in some previous classroom macro experiments.

Instructions Appendix

Overview: We are going to set up a simple economy. You will be a worker if your ID number above begins with "W," and you will be a firm if your ID begins with "F." Each worker now gets 3 black playing cards (Clubs or Spades) and each firm gets 26 red cards (Hearts or Diamonds). Black cards represent goods and services, and red cards represent money. Firms use red card money to purchase labor from workers. The black cards (labor) purchased by firms can be used to produce more black cards (goods) which can either be consumed by the firm or sold to workers for red cards. Regardless of whether you are a worker or a firm, your goal is to accumulate as many black cards as you can. The red cards are necessary, however, in allowing firms to purchase labor and in allowing workers to purchase goods.

Production: The first black card purchased by a firm produces 6 black cards (we add 5 to the original). Similarly, we add 4 black cards to the firm's second black card, 3 to the third black card, 2 to the fourth, 1 to the fifth, and none to the sixth or any additional black card. If the firm purchased 7 black cards, for example, these would be laid out and augmented by $(5+4+3+2+1+0+0) = 15$ cards as I'll demonstrate. Just as firms have a diminishing marginal product, workers have a diminishing marginal value of leisure (black cards kept). As I'll demonstrate now, we will add 2 black cards to the first one that a worker keeps, 1 black card to the second one that a worker keeps, and no black cards to the third one.

Labor Market: Each market period begins with all workers receiving an endowment of 3 new

black cards, which can be kept or sold to firms. Firms and workers begin with whatever money (red cards) that they have left over from the previous period (26 red cards for firms in the first period). Each firm chooses a wage (integer number of red cards offered in exchange for a single black card), which is written in column (1) of the record sheet on the reverse side. These wages are then posted on the blackboard, and workers are chosen in random order and are allowed to choose one or more firms with which to sell black cards for reds at the posted wage. Firms may limit the number of black cards purchased, but once a firm stops buying labor it cannot not buy from any of the other workers. The process stops when all workers have had a chance to sell labor. When workers sell a unit of labor or firms buy a unit, the cards should be exchanged on the spot and the number of black cards bought or sold is entered in column (2) of the record sheet. Workers can also keep track of the wage(s) received in column (1).

Goods Market: We then come to each person's desk and add black cards to those purchased by firms (5 added to the first black card, 4 to the second, etc.). Similarly, we add black cards to those kept by workers (2 to the first, 1 to the second). Then each firm chooses a price (an integer number of red cards demanded in exchange for each black card). This price is entered in column (3) of the record sheet, and when all firms have done this, these prices are written on the blackboard. Again we choose workers at random and let them make purchases from one or more firms. The cards are exchanged as the purchases are made, and the number of black cards bought or sold is entered in column (4) of the record sheet at the price(s) recorded in (1). Firms must sell at least one black card at the posted price but may stop selling at any time. This process stops when all workers have had a chance to make purchases.

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Earnings: At the end of a period, each firm and worker should add up the total number of black cards on hand, to be consumed, and enter this number in column (5) of the record sheet. This number of black cards determines your earnings in dollars for the period. Earnings in dollars will be added up at the end and will be discussed, but these earnings are hypothetical and will not be paid. Black cards are then collected, and each worker is given a new endowment of 3 black cards for the next period. Any red cards that you have are kept and can be used in the next period. Red cards (money) will have no value when the process ends, i.e. you can't eat your money. The end will be determined randomly with the throw of a six-sided die after the goods market. We will do two periods for sure before starting to throw the die.   Firms should now move to the front of the room and select their wages for the first period.

Record Sheet   your ID: _____   your name: _____

	(1) wage (red cards for each black)	(2) # black cards bought (by firm) or sold (by worker) in labor market	(3) price (red cards for each black)	(4) # black cards bought (by worker) or sold (by firm) in goods market	(5) # black cards accumulated at the end of period
period 1					
period 2					
period 3					
period 4					
period 5					
period 6					
period 7					
period 8					

total number of black cards accumulated (dollars earned) in all periods:

Summary of firm's production:

5 black cards are added to the 1st black card used by a firm in production.

4 black cards are added to the 2nd black card used.

3 black cards are added to the 3rd black card used.

2 black cards are added to the 4th black card used.

1 black card is added to the 5th black card used.

0 black cards are added to the 6th or higher black cards used in production.

Summary of worker's leisure consumption:

2 black cards are added to the 1st black card kept and consumed as leisure by a worker.

1 black card is added to the 2nd black card kept and consumed as leisure.

0 black cards are added to the 3rd black card kept and consumed as leisure.

REFERENCES

Brown, P.M. 1996. Experimental Evidence on Money as a Medium of Exchange. *Journal of Economic Dynamics and Control 20*: 583-600.

Clower, R. W. 1965. The Keynesian Counter-Revolution: A Theoretical Appraisal. In F. H. Hahn and F. Brechling, eds., *Theory of Interest Rates*, New York: Macmillan, 103-125.

Duffy, John, and Jack Ochs. 1996. Emergence of Money as a Medium of Exchange: An Experimental Study," working paper, University of Pittsburgh.

Evans, George W., Seppo Honkapohja, and Ramon Marimon. 1995. Convergence in Monetary Inflation Models with Heterogeneous Learning Rules. Working paper, Universitat Pompeu Fabra.

Hey, John D. and Daniela di Cagno. 1996. Money in Markets: An Experimental Investigation of Clower's Dual Decision Hypothesis. Working paper, University of York, forthcoming in *Experimental Economics*.

Lian, Peng and Charles R. Plott. 1993. General Equilibrium, Macroeconomics, and Money in a Laboratory Experimental Environment. Social Science Working Paper 842, California Institute of Technology.

McCabe, Kevin A. 1989. Fiat Money as a Store of Value in an Experimental Market. *Journal of Economic Behavior and Organization 12*: 215-31.
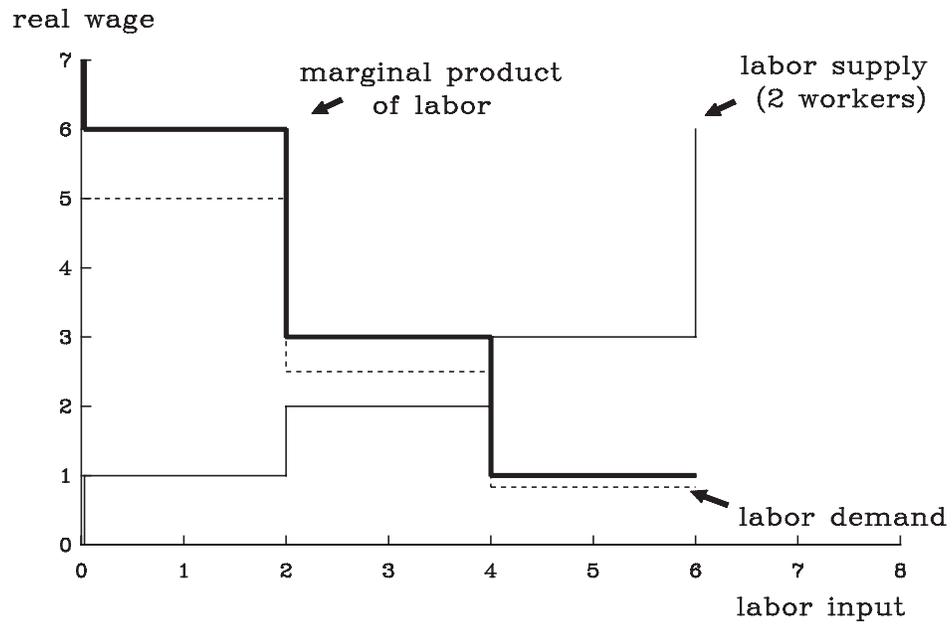
Figure 1. Supply and Demand for Labor
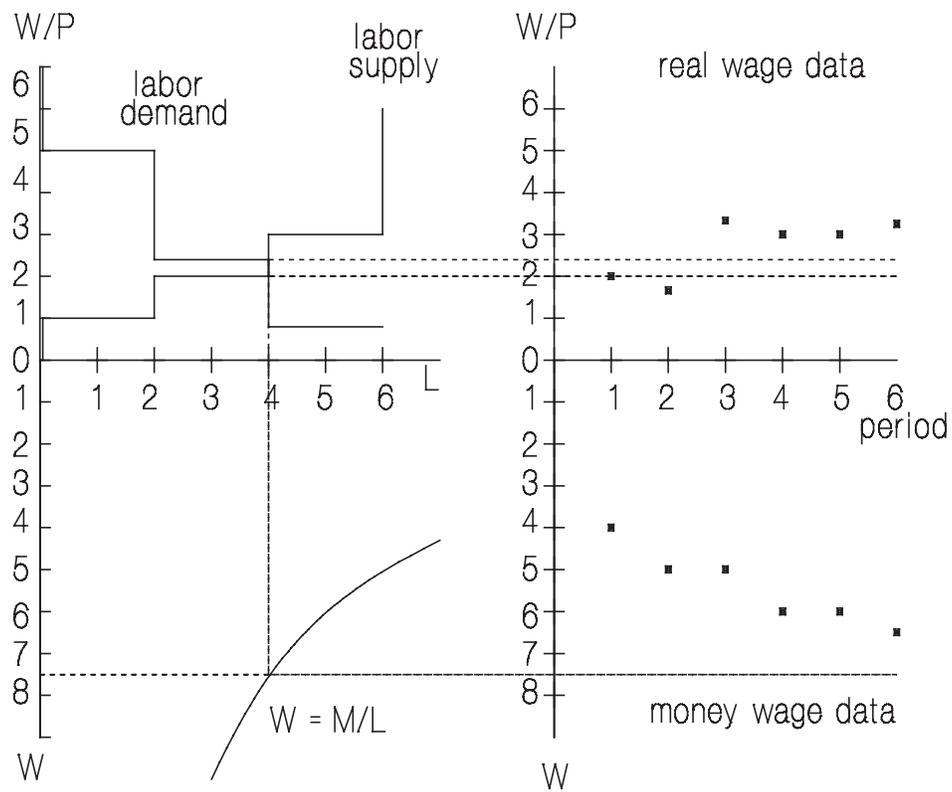(one firm, two workers, probability of termination = 1/6)

Figure 2. Theory and Data for a Classroom Macro Economy

Endnotes

1. The instructions in the Appendix imply a marginal product curve that has more steps, with declining marginal products of 6, 5, 4, 3, 2, and 1.

2. As a take-home exercise, you can ask students to graph total, marginal, and average products of labor.

3. The easiest way to do this is to give each worker a number, in sequence from 1 to the number of workers, and use the throw of a die to determine which worker starts. For example, with 10 workers, you could use a 10-sided die (sold at most game stores) to select the first worker. If the throw were 9, for example, then worker 9 is first, worker 10, second, worker 1 third, etc.

4. A technical derivation of the demand for labor curve when the probability of continuing is less than one is something that can be discussed in an intermediate macro class. Selling one more unit in period t will reduce the firm's consumption by 1 in that period, but will enable the firm to purchase P_t/W_{t+1} units of labor in the next period, i.e. $L_{t+1} = x_t P_t/W_{t+1}$, where x_t denotes sales quantity in period t. Now let r denote the probability of termination, and $f(L)$ the production function, so the relevant part of the firm's dynamic objective function is:

$$- x_t \quad + \quad (1 - r) f\left(P_t x_t / W_{t+1}\right),$$

which is maximized when with respect to x_t when: $- 1 + (1-r) (P_t/W_{t+1}) f'(L) = 0$, where $f'(L)$ denotes the marginal product of labor. In other words, the sales increase until the loss of one unit of consumption equals the probability of continuing, $1-r$, times the amount of labor that can be purchased, P_t/W_{t+1}, times the marginal product of labor. The time subscripts can be dropped

in a steady state, and the above first-order condition can be rewritten as: $W/P = (1-r) f'(L)$, i.e. the marginal product of labor curve shifts down by a factor that is the probability of continuation. In our setup, the probability of continuation is 5/6, which explains the location of the dashed labor demand line in Figure 1, relative to the marginal product line.

5. We had no problem with stopping in this manner, "to save time for discussion." An alternative would be to compensate anyone holding red cards by converting these to black cards at a rate determined by the average commodity price for the (unannounced) final period. This should not be announced in advance, as it may affect wage and price decisions. This action will be viewed as being fair, and we think it is a reasonable compromise, although this type of deception should not be used in a research experiment.

6. Depending on the level of the class and what comes up in discussion, you may go to explain that there is a slight downward shift in the marginal product curve to get the labor demand in a steady state when the probability of continuing is less than one.

7. There were two firms and four workers, with one of the "workers" consisting of a two-person team. The termination probability actually used was 8/10, not 5/6, which is reflected in the position of the labor demand curve.

8. We encountered a few classes in which the real wage is at or below 2, especially in early periods.

9. The velocity of money is one, since each red card circulates through the labor and goods markets exactly once when excess cash is not held. Thus $WL = PY = M$, when output Y, money M, and labor L are measured in units per firm. The $PY = M$ condition is essentially the quantity theory of money when velocity is one.

10. In this experiment we used a fixed money supply of 30 instead of 26.