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The Effects of a Minimum Wage on the Labor Market: A Complex Perspective

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Abstract

In this paper we adopt a different approach to understand a labor market. We built a competitive labor market from the bottom-up; it is composed by four kinds of employees and four kinds of employers. In the simulation employees and employers act to reach a minimum level of satisfaction (on the lines of Simon, 1947; and Axtell and Epstein, 1996), which means that they don't follow a utility maximizing behavior. With a few basic rules we were able to determine the effect of a minimum wage on unemployment rates, total wages, and average wages in the different populations. Our labor market is dynamic; and therefore significantly different than the standard supply and demand approach. The model can also operate under both, competitive and monopsony assumptions. Another advantage of the model is that it is possible to make changes on the parameters and evaluate the effect on the independent variables. Our results conform the theoretical agreements and offers evidence for increasing minimum wage elasticity, especially in the case of subjects defined as immigrants and teenagers. In the monopsony case the results also resemble those predicted by the theory, however we found that at high levels of the minimum wage, the wages for the total economy decrease, the effects for each group, however are not clear and show a complex pattern.

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I. Introduction:

The literature on minimum wages is extensive. It was George Stigler's seminal paper that called economists' attention to the causes and effects of minimum wages. As pointed out by Stigler, the purpose of the minimum wage legislation—the elimination of poverty—is not seriously debatable; but the important question is if indeed the legislation fulfils this purpose. Stigler concludes that a minimum wage does not satisfy its original intentions, and will tend to increase unemployment and reduce family income (Stigler, 1946). Stigler's conclusions have been supported by subsequent empirical research (Burkhauser and Finnegan, 1993; Gramlich, 1976). These results leaded to a virtual professional consensus in the late 1960s that a minimum wage is a poor anti-poverty devise (Lal, 1995, p. 12). However, recent studies have relied in the idea that if the labor market is not competitive but present characteristics of a 'company town' (the monopsony case) a minimum wage set at the competitive level would increase employment and the efficiency of the economy. As a result the relevant discussion focused in finding out if industries had monopsonist features. Brown (1988) for instance, argues that the monopsony case is a textbook *curiosum*. McKenzie and Tullock (1978), however, discuss some evidence of monopsony in a few industries like the professional football in the USA[1].

More recently Card and Krueger studied the case of the fast-food restaurants in New Jersey and eastern Pennsylvania, before and after the rise in New Jersey's minimum wage in April 1992. They found that, compared with restaurants in eastern Pennsylvania where the minimum wage remained unchanged, the restaurants affected by the minimum wage in New Jersey *increased* their employment—at a time when the economy was in a recession. This would be in consonance with the monopsony model (Lal, 1995). In more recent publications[2] Card and Krueger conclude that on past US studies 'under close scrutiny, the bulk of the empirical evidence on the employment effects of the minimum wage is shown to be consistent with our findings… which suggest that increases in the minimum wage have had, if anything, a small, positive effect on employment, rather than

[1] McKenzie and Tullock claim, nevertheless, that even in such industry collusion is particularly difficult.
[2] *Myth and Measurement – The New Economics of the Minimum Wage*, Princeton, New Jersey: Princeton University Press, 1995.

an adverse effect' (Lal, 1995 p. 20). Carl and Krueger's studies have been criticizes in many fronts. For example, Neumark and Wascher (1995) found that in the same period using payroll data the New Jersey minimum wage (of 18.8 percent) resulted in an unemployment increase of 17.6 percent relative to the Pennsylvania control group.

In this paper we depart from the conventional analytic-econometric method and analyze the effects of minimum wage through an agent based labor market, built from the bottom up and following very simple rules. There are four kinds of employees (adults, adults with family, illegal immigrants, and teenagers), and four kinds of employers (those who comply with immigration and minimum wage laws, those who comply with neither, and two groups that each comply with only one or the other law). We found that in a market with several employers (an approximation to the competitive textbook example) there is a direct relationship between a minim wage and the unemployment rate; the minimum wage creates unemployment. The higher rates of unemployment prevailed in the illegal immigrant population at different levels of minimum wage. In addition, at low levels of the minimum wage subsequent increments (minimum wage elasticity of unemployment) had greater effect on the immigrants; at relatively high levels the effect was greater on the teenager population. For the total economy, changes at low levels of the minimum wage the minimum wage elasticity is .08, which is similar to .06 of some analytical studies done in the UK (Kaufman, 1989). The increase in the minimum wage increases both, the average wage and the total wage across the different populations, but the marginal effect is decreasing.

Finally, in the case of one employer (an approximation of the monopsony case) our results conform the theoretical predictions, at low levels of the minimum wage; an increase in the minimum wage decreases unemployment, subsequent increases reduce employment. The results for each group, however, behave in a complex way. Interestingly, at high levels of the minimum wage, total wages tend to decrease, due mainly to the decrease in total wages within the adult with family population. The minimum wage elasticity of unemployment is relatively lower in this case than in the competitive situation.

This paper will cover the theoretical framework used to construct the model. Then, the action, interface and use of the model will be detailed. We then cover the results and insights, followed by verification and validation issues. The paper ends with a discussion of further ways in which the model may be extended.

2. The Model:

We assumed a competitive labor market that can easily be converted into a monopsonist market by reducing the amount of employers to one.[3] We included some employers that do not comply with certain regulations. In this sense our model is more realistic than the standard static model of supply and demand. The standard microeconomic models normally illustrate the effects of minimum wage in a comparative static scenario; the model we developed is dynamic and allows evaluating how unemployment changes when the parameters change. In addition, the simulations let us make forecasting of average wages, total wages, and rates of unemployment in our artificial society. These capabilities are hardly found in the current literature.

The simulation is validated at the "second level" which means that our variables have the right signs; the numerical results in the artificial labor market are quantitatively similar—not equal—to the variables in the US labor market.[4]

The Action:

Employees step forward randomly from the pool of the unemployed, randomly choose an employer, and attempt to trade labor for wages. The wage that the employee asks is chosen randomly from a range between the minimum that each type of employee will work for (a constant), and a maximum based on the employee's experience level (that is a proxy variable for productivity), which is also constant. The constants are as follows:

- teenager = minimum accepted wage 5, experience / qualification level 1;

[3] The source code can be send under request to amarroqu@gmu.edu

[4] A logical extension of the model is the inclusion of a good market, produced by employers' firms. This addition would allowed us to determine if an increase in the minimum wages increases inflation, given different levels of the price elasticity of demand of the product. In other words, an increase in the minimum wage might reduce the real wage without affecting the rate of unemployment.

- illegal immigrant = minimum accepted wage 2, experience / qualification level 1;
- adult = minimum accepted wage 10, experience / qualification level 2;
- adult with family = minimum accepted wage 15, experience / qualification level 3.

The teenager and illegal immigrants are assumed to have the same (and lowest) amount of experience and/or qualifications. The teenagers however are more demanding of wages than the illegal immigrant. The adult represents a younger adult with medium experience and/or qualifications—such as a recent college graduate or someone with a few years of working experience, and the adult with family represents someone who is further along in his/her career thus has more experience and qualifications (i.e. graduate school).

Employers choose the working conditions they offer randomly from the maximum working conditions set for each group by a slider. Employees have a minimum working condition they will accept as follows: illegal immigrant = 1, teenager = 2, adult = 3 and adult with family = 4. The employees are expected to become more selective based on the experience and/or qualifications they are able to offer the employer. Employers are constrained by the total amount of funds they have with which to pay wages.

If, when the employee moves, he/she lands on a blank space, he/she will move back to the unemployment line without attempting to trade—representative of an employee approaching an employer who is not currently hiring. Also, if he/she is an illegal immigrant, and lands on an employer who is compliant with immigration laws, he/she will also return to the unemployment line, being rejected due to illegal status. Finally, if the employer is out of money, the employee moves back to the line.

If the employee lands on a random employer other than the above, the pair will attempt to trade work for wages. Once the employee lands, the employer decides the wage he/she will offer, based on the desired experience level, which is also decided at that moment. Employee and employer compare criteria and, if they match, the employee is hired, and

lines up behind the employer. If not, the employee returns to the unemployment line to try again.

The Interface:

On the interface there are sixteen rows of dots (in four colors) lined along the left hand side of the display. These are the employees in their unemployment lines. Each color represents a group: blue = teenager, green = adult, red = adult with family, and yellow = illegal immigrant. Lined up in the button, the employers (who are hiring) are the black squares. You will see that the employers' field is divided by varying shades of gray. This is to represent the different groups of employers based on their compliance as described above.

The sliders affecting the employers are also grouped by compliance, next to the groups they affect. The slider groups are identified by the following: *nc-all* = those employers who are non-compliant with immigration and minimum wage laws, *nc-imm* = those employers non-compliant with immigration laws only, *nc-wage* = employers non-compliant with minimum wage laws only, and *c-all* = those compliant with both immigration and minimum wage laws. In each group, there is a slider for *initial* number of employers; *max*imum working *cond*itions that can be offered in each group, and the *max*imum *funds* any employer in the group has available to pay wages.

On the left hand side are sliders to adjust the federally mandated minimum wage, and the overall maximum number of employees with which to begin. The program will randomly distribute this maximum among the four employee groups.

At the button, there are monitors for the average wage, time elapsed and unemployment rate. The average wage is the average agreed-upon wage over all groups, which is updated as new trades occur. The time elapsed tracks the number of periods the program has run. The unemployment rate is the percentage of employees left in the unemployment line, based on the initial number of employees chosen.

Below the command center are monitors that track the unemployment rate and average wages for each group. The graphs at the bottom display average wage overall and unemployment rates for each group.

3. Results:

3.1 The competitive case:

In order to evaluate the effect of an increment of the minimum wage, we conducted two experiments. The first incorporated employers and employees of all groups. The second involved only one employer who is compliant with all regulations.

For the first experiment, we set the parameters of the model as in the following table:

Employer type	Initial number	Max working conditions	Max funds
Non-compliant all	16	3	200
Non-compliant immigration laws	16	4	200
Non-compliant minimum wage laws	16	3	200
Compliant all	14	4	400

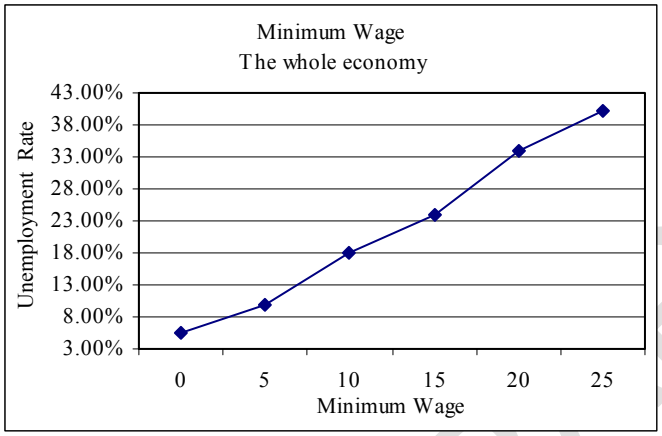
Table 1: *Initial conditions*

The initial number of employees has been set at 300. The only variable altered in this experiment is minimum wage. The number of periods the model was permitted to run was set at 2,500, and the model was run thirty times with the minimum wage set at each of the different levels of minimum wage (0, 5, 10, 15, 20, and 25, monetary units). The results are summarized in Table 2.[5]

As expected, in the whole economy and in each of the different population the minimum wage is positively correlated with the rate of unemployment, Graph 1.[6] However, the

[5] To see the detailed results of the simulations see tables 3–8 in the appendix.
[6] The differences in unemployment are sadistically significant at each level of the minimum wage, Appendix 1, Table 1.

results for the whole economy suggest that the marginal effect of a change in the minimum wage is positive (increases in the minimum wage at higher levels increase the unemployment rate more than proportional), this is showed by a positive trend in Graph 2.

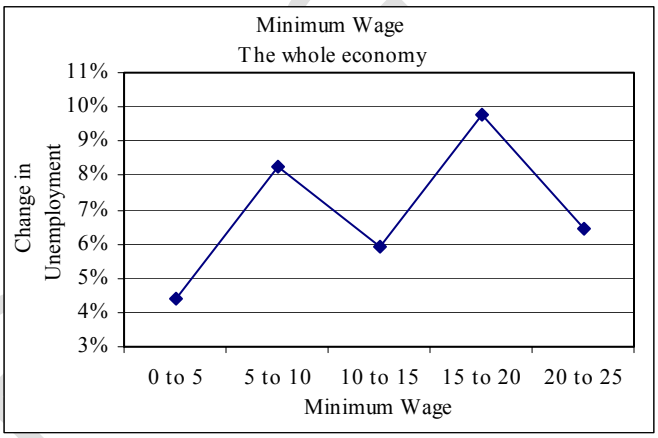


Graph 1: *Minimum wage vs. unemployment rate for the whole economy*
30 iterations at each level of minimum wage

	Minimum Wage					
	0	**5**	**10**	**15**	**20**	**25**
Whole Economy						
Unemployment Rate	5.49%	9.88%	18.13%	24.08%	33.87%	40%
Change		4%	8%	6%	10%	6%
Total Wages	5619	6621	7512	8124	8346	8654
% Change		18%	13%	8%	3%	4%
Average Wage	20	25	31	36	42	49
% Change		24%	25%	17%	18%	15%
Adult Population						
Unemployment Rate	1%	0%	1%	3%	10%	14%
Change		-1%	1%	2%	7%	4%
Total Wages	1737	1928	2370	2710	3022	3206
% Change		11%	23%	14%	11%	6%
Average Wage	24	27	32	38	45	51
% Change		13%	21%	17%	17%	14%
Teenagers						
Unemployment Rate	2%	3%	9%	17%	30%	37%
% Change		1%	6%	7%	13%	8%
Total Wages	706	1060	1275	1558	1545	1613
% Change		50%	20%	22%	-1%	4%

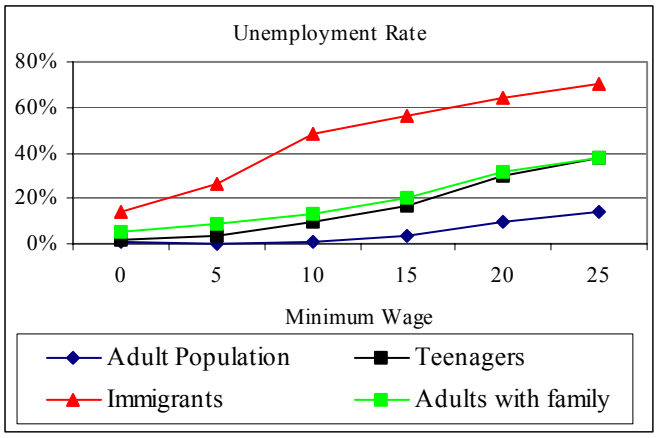
Average Wage	10	15	20	25	30	35
% Change		51%	35%	25%	22%	17%
Immigrants						
Unemployment Rate	14%	26%	48%	56%	64%	71%
Change		12%	22%	8%	8%	6%
Total Wages	462	672	675	712	727	717
% Change		45%	1%	5%	2%	-1%
Average Wage	7	12	18	23	29	34
% Change		69%	43%	28%	25%	19%
Adults with family						
Unemployment Rate	5%	9%	13%	20%	31%	38%
% Change		4%	4%	7%	12%	7%
Total Wages	2714	2961	3191	3143	3053	3118
% Change		9%	8%	-2%	-3%	2%
Average Wage	38	44	48	54	61	69
% Change		14%	11%	11%	13%	13%

Table 2: *Main results of the effect of the minimum wage for the whole economy and each group of employees*

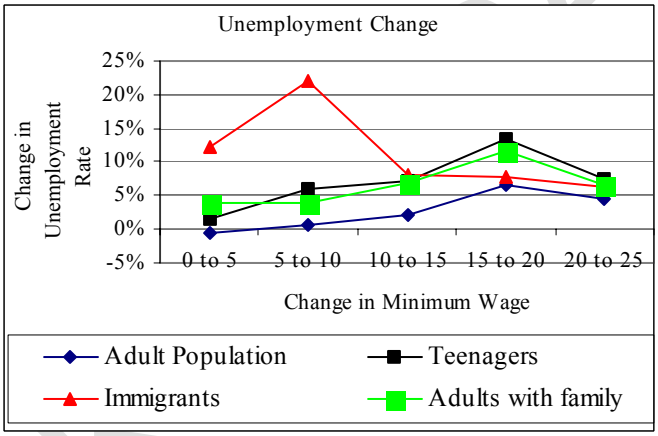


Graphs 2: *Minimum wage vs. Change in unemployment*

The rate of unemployment in the immigrant population is significantly higher that other population. This gap increased when the minimum wage goes from 5 to 10, Graph 3. In addition, as predicted by the standard models, the marginal effect is greater for those employers with the lowest productivity—lowest experience—, immigrants and teenagers, Graph 4.



Graph 3: *Effect of the minimum wage in each group*



Graph 4: *Marginal effect of the minimum wage in each group*

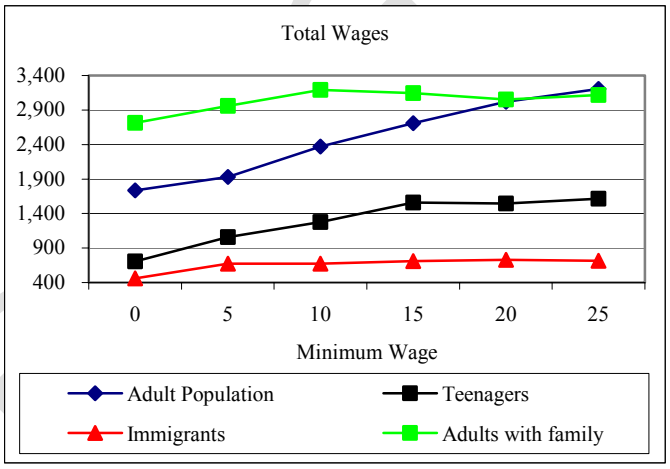
In order to determine the effect of the minimum wage in the different groups we consider the marginal effect in the unemployment rate due to a percentage change in the minim wage (minimum wage elasticity).[7] These results are presented in Table 3. The elasticity of the minimum wage tends to increase at higher levels of the minimum wage. This implies that a percentage change in the minimum wage has a more than proportional effect on the percentage change of unemployment. With the exception of illegal immigrants this trend is reverted when the minimum wage increase from 20 to 25.

[7] The elasticity of the minimum wage is defined as percentage change on unemployment divided by the percentage change in the minimum wage.

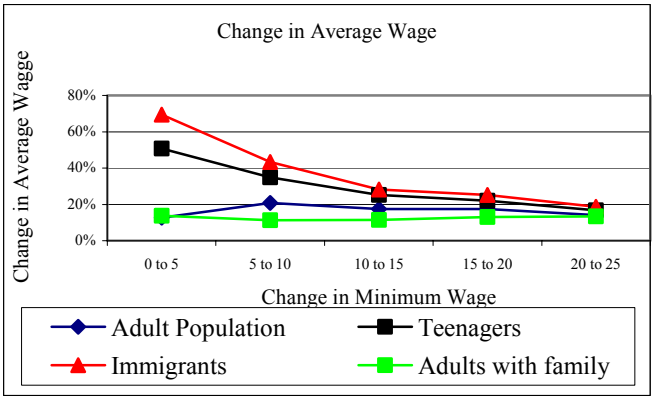
	Change in Minimum Wage			
	5 to 10	10 to 15	15 to 20	20 to 25
Total	0.08	0.12	0.29	0.26
Adult Population	0.01	0.04	0.20	0.18
Teenagers	0.06	0.14	0.40	0.30
Immigrants	0.22	0.16	0.23	0.26
Adults with family	0.04	0.14	0.35	0.27

Table 3: *Minimum wage elasticity of unemployment*

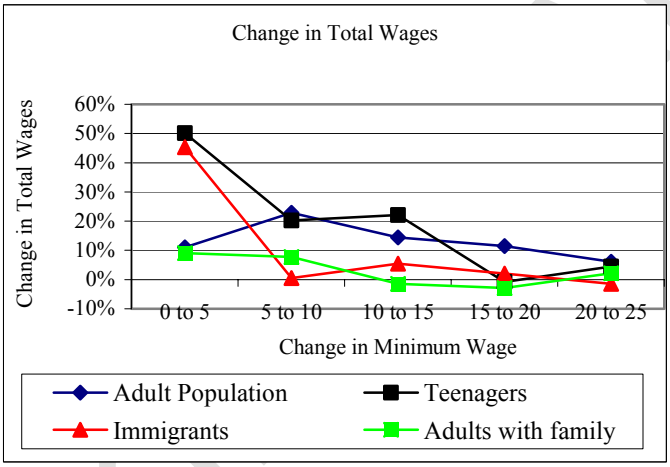
The increases in the minimum wage has a positive effect in both, total wages and average wage, which is not surprising since those who stayed employed, after an increase in the minimum wage, are usually workers with high productivity—high experience—, adults with family and adults; Graph 5. However, as seen in Graph 6, there is decreasing marginal change in average wages as the minim wage increases. In the case of total wages, the effect is less clear Graph 7.



Graph 5: *Total wages for each group at different levels of the minimum wage*



Graph 6: *Effect of the change in the minimum wage on average wages for each group*



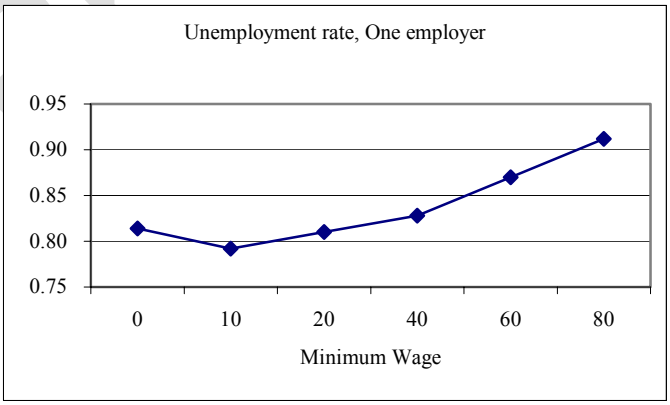
Graph 7: *Effect of the change in the minimum wage on total wages for each group*

3.2 The monopsonist case:

The microeconomic model for the monopsony case suggests that with the introduction of an effective minimum-wage law, the monopsonist employer is *forced to be a price taker* (Hirshleifer, 1992: 339). Within a range, an increase in the minimum wage will equaled the marginal factor cost (price of the factor times the marginal cost) with the marginal revenue product (marginal revenue times marginal product) at a higher level of employment. [8]

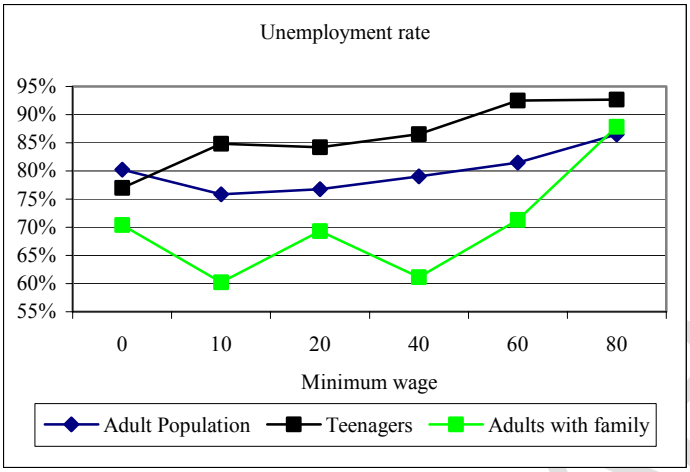
[8] A clear exposition of the model can be found in Hirshleifer (1992: 338-44).

We reduced the number of employers from 62 in the competitive model to 1 (employer of the type compliant all, with 1,000 monetary units available) to approximate the monopsonist case; and reduced the number of employees to 50. We kept the other conditions as in the competitive model. We run 10 simulations for each of six different levels of the minim wage. For the whole economy, the results conform the theory; there is a minimum wage that increases the level of unemployment (this minimum wage is around 10 monetary units). After this level, however, increases in the minimum wage increase unemployment, Graph 8.[9] The increase in the minimum wage tends to benefit the teenager group, Graph 9. The marginal effect of the changes of the minimum wage on the different population is less clear, and more complex, Graph 10. According to graph 10, the reduction in unemployment for the whole population is due to the reduction in unemployment in the teenager group. Although the increase in the minim wage from 20 to 40 reduces unemployment in the adult with family population this change is not large enough to reduce the rate of unemployment for the whole population. For the parameters defined, the minimum wage elasticity of unemployment is relatively lower than it is in the case of the competitive market, Table 4. It is of note that at high levels of the minimum wage, the total wages for the whole economy tend to decrease, Graph 11; this effect is mainly due to the reduction of the total wages in the adult with family group, Graph 12.

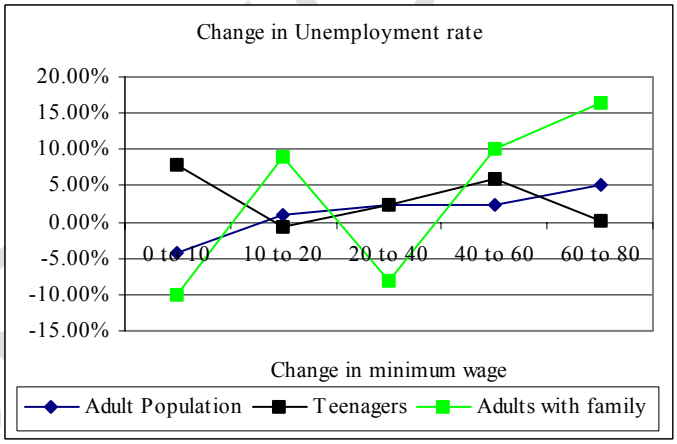


[9] The differences are not statistically significant. The differences in unemployment have to be compute between relatively high differences in minimum to get statistically significant differences. Appendix 1, Table 2.

Graph 8: *Unemployment rate at different levels of the minimum wage, the monopsonist case*



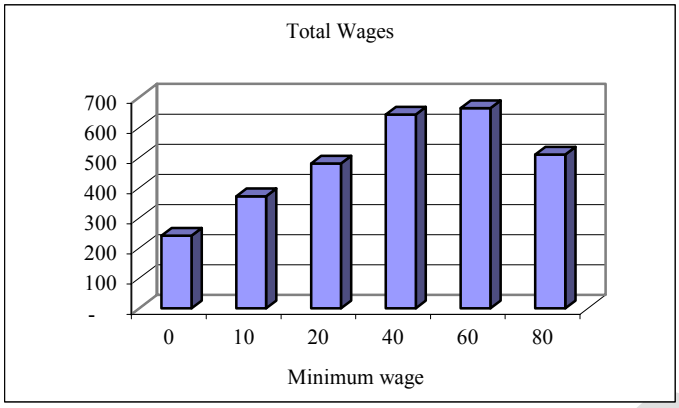
Graph 9: *Unemployment rate for each group*



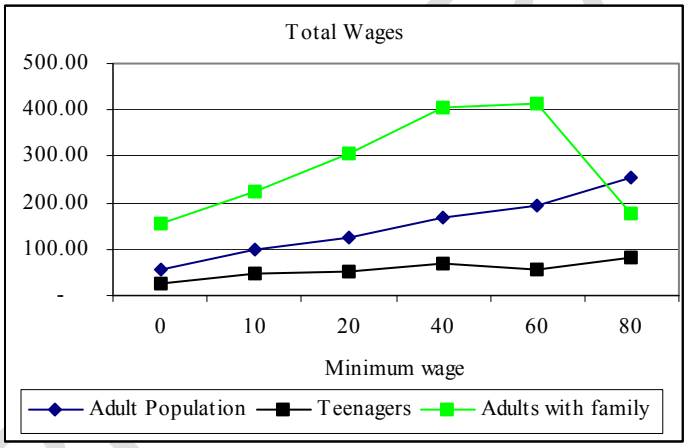
Graph 10: *Marginal effect of changes in the minim wage on each group*

	Change in minimum wage			
	10 to 20	**20 to 40**	**40 to 60**	**60 to 80**
Elasticity	0.02	0.02	0.08	0.13

Table 4: *Minimum wage elasticity of unemployment. the monopsony case*



Graph 11: *Total wages for the whole economy at different levels of the minim wage, the monopsony case*



Graph 12: *Total wages for each group at different levels of the minimum wage, the monopsony case*

4. Verification and Validation

It is worth noting that some of our results are consistent with empirical work done by Kaufman (1989), who calculated a .06 employment elasticity, our model calculated an minimum wage elasticity of .08 for the whole economy—at low levels of the minimum wage—in the competitive case; and of .02 in the monopsony case. This is an interesting result given that our model departs from very simple rules based in subjective valuations of employees and employers.

The model is verified in the first two levels of verification and validation: there is a micro and macro correspondence between the model and the current results in the literature. In two important ways:

1. Our model predicts an increase in the rate of unemployment as a consequence of an increase in the minimum wage. In the recent literature, a minimum wage set higher than the previous equilibrium would be expected to cause disemployment [an increase in unemployment] among low wage groups. According to a survey by Alan Hochstein, of 13 studies published between 1970 and 1978, 12 reported that minimum wage laws were associated with significant reduction in employment, while four reported no significant effect. (Hirshleifer, 1998, p. 341.)
2. Our model also predicts a larger effect in the case of less skilled workers (immigrants and teenagers). This also supports the available evidence (Deere et al, 1995, p. 48). [Deere's] study indicates that age-sex groups with the highest proportions of low wageworkers—most notably the 15-19 age groups—generally suffered the largest proportionate reduction in unemployment. (Hirshleifer, 1998, p. 342).

IV. Discussion:

Our results show that when agents follow basic rules, we could generate outcomes that resemble the theoretical microeconomic predictions. Some of our results, however are novel, and are hard to observe with the standard econometric models. For example, the increase in the minimum wage elasticity of unemployment as the minimum wage increases in the competitive instance; or the reduction in total wages at relatively high levels of the minimum wage in the monopsony case. In addition, the model allowed us to change parameters leaving other factors constant, like in the case of reducing the number of employers to approximate the textbook monopsony situation. In some cases we observe very complex outcomes, like the effect of changes in the minim wage over each population in the monopsony case. Our model was not developed with the intention to subscribe any public policy action, but with the purpose to understand how the labor markets operate in a way that hasn't been explore in the past.

V. Possible extensions to the model:

a.

A logical extension of the model is the inclusion of a good market, produced by employers' firms. This addition would allowed us to determine if an increase in the minimum wages increases inflation, given different levels of the price elasticity of demand of the product. In other words, an increase in the minimum wage might reduce the real wage without affecting the rate of unemployment.

b.

It would be possible to build in a procedure where if the unemployment rate was maintained after a certain number of runs, the program would automatically stop, but that has not been done here. The program could also be tailored to stop when a certain level of unemployment has been reached, or a certain percentage of employers max out their payroll.

Another major extension would be to allow employees to evolve as time goes on. They could decide to change jobs after a period of time, building up experience as they progress through life. These employees were given infinite lives, however the employees in this suggested extension would have finite lives. They would start out as teenagers, get their first job, then move and gain experience as they age and finally retire.

The employers could be programmed to go out of business randomly, thus laying off workers and adding to the unemployment rate. Perhaps during the period up to this point, the working conditions could decrease, prompting some employees to leave prior to being laid off, in order to find better conditions.

One final suggestion is to have the employers choose appropriately qualified employees from the group of candidates, much the same as occurs in the officer ranks of the U.S. armed forces. In fact, adapting this model to that of the armed forces causes a whole new set of rules to be written including those pertaining to time in grade, time in service, and individuals marked for the 'fast track' route. This would not address the minimum wage issue, but would address some other pressing issues in the armed forces such as gaps between supply and demand of officers in particular jobs or fields.

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Appendix 1:

Competitive case

	Change in Minimum Wage				
	0 to 5	**5 to 10**	**10 to 15**	**15 to 20**	**20 to 25**

Competitive Model	3.49	6.80	4.87	7.98	5.16

Table 1, appendix 1: *t statistics differences in unemployment averages at different levels of the minimum wage*

Monopsony case:

	Change in Minimum Wage				
	0 to 10	**10 to 20**	**20 to 40**	**40 to 60**	**60 to 80**
Monopsony case	0.55	0.40	0.46	1.37	1.75
					10 to 60
					2.16

Table 2, appendix 1: *t statistics differences in unemployment averages at different levels of the minimum wage*

Appendix 2: To use the model

Adjust the sliders, click setup and then go. You can adjust the initial number of employers in each group, the maximum initial working conditions employers in each group can offer, and the maximum amount of funds each employer has from which to pay wages. Decide the maximum number of employees you would like (the allocation among employee group types will happen randomly) and the federally mandated minimum wage.

The program stops under the following conditions, as follows:

1. All employers run out of wage money
2. All of the employees are hired
3. After a preset number of runs

It is also possible to set the criteria so that the program reaches a point where a certain level of unemployment is maintained and no other trades can be made. In this case, the current program will continue to run, until manually halted.