The Dynamic Consequences of Public Employment : An Agent Based Approach

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A model of the market with heterogeneous firms and individuals is introduced, and public sector employment is investigated. There are three types of agents, consumers, firms and public sector firms or bureaus. Consumers work at either a private firm or a bureau. Private firms and bureaus start on an equal footing, with normally distributed capital and technology and bid on workers in a labor market. Private firms use a simple learning algorthm to set price, and bid freely for workers up to the marginal benefit of the worker to the firm. Bureaus use fixed wages and prices determined as parameters to the model. A progressive tax rate funds public sector employment. Simulations show that it is not only the effect of taxation, but also competition by the bureaus, that affects the wages and profits in the private sector. This model provides a new approach to the study of employment policy consequences.

Introduction

Economists have long debated whether government can effectively reduce perceived failures of the market such as involuntary unemployment, business cycles, and wage inequality. Government can act through market intervention or with a supplementary public sector system. Though the intention of public employment is to supplement the workings of the market, it may affect the functioning of the private sector.

The market is complex adaptive system, made up of heterogeneous interacting agents. The macroeconomy is an emergent process, driven by these interactions. Macroeconomic models, such as general equilibrium models, are unable to capture all of the unintended consequences of government action, as they necessarily must abstract away from the underlying interactions of individual actors. An agent based model builds from accepted micro-level behavior and can inform macro models as to the expected effect on the private sector of government action. Agent based modeling has been used to study the market before (Neugart (2008), Tesfatsion (2001)).

Here I present an agent-based model of the labor and product market in which a public sector in the form of an Employer of Last Resort program (ELR) is introduced, and crowding out effects are investigated. The model offers a complex learning environment where heterogeneous agents with uncertainty and incomplete information interact. Heterogeneous firms offer their product at different prices according to

capital and labor cost considerations. As firms grow and learn and fail, the market adapts. In such a system the emergence both of market failure and of unintended consequences becomes possible.

Background

Models that assume complete information and perfect competition suffer from an inability to illustrate dynamic market characteristics such as entrepreneurship, market power and market failure (Hayek (1937);McNulty (1968)). Static models (which may start from a presumption of market failure and introduce government intervention) suffer from the inability to illustrate the dynamic consequences of the policy, which may differ from first-round effects (Baldwin (1992)). Traditional dynamic macroeconomic models that explore market failure suffer from their aggregation and homogenization of individual behavior, hiding the trade-offs that necessarily occur among individual transactions and which may lead to significantly different outcomes than predicted (Kirman and Zimmerman (2001)).

The agent-based approach allows for micro-level behavior and interaction of heterogeneous agents to lead to the emergence of a macroeconomic environment capable of market failure, growth and unexpected policy consequences (Hommes (2005)). A true microeconomic foundation for macroeconomics must be built upon a system that allows for interactions between individuals to produce an emergent macroeconomy. This is the only way for gains from exchange, and policy consequences that aid or interfere with coordination to be modeled. Macroeconomics without this foundation proceeds as if the aggregate outcomes in the economy can be chosen - that they are choice-theoretic. But in reality, the choices of individuals within the economy simply to lead to those aggregates. A well-founded macroeconomics must allow the macro to emerge from the micro (Wagner (2005)).

One failure of markets often described by economists is the highly unequal distribution of incomes which may be produced by a market economy. Government can solve this market failure through taxation and redistribution, or more broadly by a set of policies including public sector employment, subsidies, tariffs and price controls for favored industries, unemployment insurance and welfare programs.

Common arguments against these policies often center around incentive and behavioral consequences which may reduce output growth in the economy by discouraging work and investment. For example, high taxes reduce the incentive to expand production, work toward a promotion or to save and invest; unemployment and welfare programs encourage some not to work at all; and public and protected employment encourage laziness on the job.

Policymakers are aware of the concerns about incentives. Policies like the Earned Income Tax Credit aim to counter the negative incentives of welfare and unemployment insurance, and taxes are often set with behavioral effects in mind. An Employer of Last Resort policy is another way that government might redistribute from the wealthy to the poor in a society. By taxing progressively, government can employ

workers at a higher wage than private firms seeking profit would be able to.

In the United States there have been governmental attempts to employ out-of-work citizens (Bell and Wray (2004)). Some have argued that these programs are not economically sound (Gelb et al. (1991)); yet there remains literature supporting the policy of government as "employer of last resort". For example, government employment may influence the ability of the private sector to employ workers. ((Malley and Moutos, 1996)). A proposal for an Employer of Last Resort (ELR) program was described in the Eastern Economic Journal for the European Monetary Union in 1999 (Kregal (1999)). ELR proponents argue that wages would be stabilized by the policy as the wage chosen by the public sector – the "policy" wage rate – would be a fixed point around which the overall wage level would be determined. If market wages fell too much, the public sector would expand to take in new workers unhappy with private sector wages, and as market wages went up, public workers would exit to join the private sector.

For this program to work as expected, the private sector must remain strong. Otherwise the market wages could not rise and encourage the movement of workers out of the public sector. There is some evidence that countries with more heavily regulated or unionized labor markets, such as Sweden, have longer and deeper recessions (Agell and Lundborg (1999)). Sweden has experimented with both wage rigidity due to collective bargaining and Bureaus that act as employer of last resort (Skedinger and Widerstedt (2003)). In 1998 Sweden abolished its "relief works" program, which had been part of active labor market policy and had acted as an employer of last resort program but had been found to crowd out private employment (Calmfors et al. (2002);Malley and Moutos (1996)).

While incentive effects of taxation and other intervention are well studied, fewer economists have focused on the non-behavioral based effects of government redistribution programs, such as the effect of public sector competition on private sector wages. The model presented here aims to address this gap.

Purpose of the Model

The model presented is composed of heterogeneous consumers and firms which interact and affect each other's states. Firms use learning to continually adjust price on the basis of profit, so that firms' decisions are actually affected by the outcome of the policy on other firms, and the macroeconomic outcome is an emergent property of the model. If government employment has no negative effects on the private sector, and changes in incentive structure are the only cause of inefficiency, then public sector employment, even if it crowds out private sector employment, would result only in a transfer from those taxed to those employed by the program, with no loss in total output and no increase in unemployment. If wages in the public sector are higher than private sector wages for those workers then a reduction in poverty should be

seen. With efficiency in the market and no dead weight loss, pure redistribution of wealth would occur. On the other hand, if inefficiencies still emerge with public sector employment, this would suggest that there are unintended consequences of having a non-profit maxmizing firm with the power to tax competing with the private firms. Evolutionary dynamics of the market are also important to consider. For example, the hard budget constraint produces a natural selection process, and price and wage-setting according to profit in heterogeneous firms provides a decentralization of production according to economies of scale and comparative advantage

Modeling these programs as public employment ensures the government an equal footing with the private sector. Public and private firms start with the same initial distribution of capital, and ability to train workers. Incentives and behavioral effects are ignored[1]. The difference between public and private firms include only their price and wage setting logic, and budget contraints. This should isolate any remaining inefficiencies.

The Model

The economy begins with an initial set of agents N, which are of three possible types, individuals, private firms and public bureaus, and a government which enforces rules and directs the bureaus. The set I is composed of individuals, and grows at a rate n. Private firms F and bureaus B make up the rest of the agents. Individuals may also become private firms, representing entrepreneurship.

An individual agent $i \in I$ has a productivity endowment $\gamma \in (0, 1]$. The individual may train later to improve this productivity. Firms and Bureaus also train workers on the job, based on a simple probability.

A private firm agent $f \in F$ has an initial technology endowment A taken from $A \sim N(0.15, 0.5)$ and an initial capital endowment where $K \sim N(1.5, 5)$.

The government G has a policy parameter λ which determines the size of the public sector, and hence the extent of hiring by the Bureas. Government also has a policy parameter φ determining whether the program should be responsive to the unemployment rate, expanding if unemployment gets worse, in order to soak up the excess labor, and shrinking if unemployment falls. A Bureau agent $b \in B$ has an initial technology endowment $A \sim N(0.15, 0.5)$ and an initial capital endowment where $K \sim N(1.5, 5)$.

[1] Two behavioral results are retained in this model which also may affect the outcome: training and entrepreneurship depend partly on the expectation of increased earnings. Hence, if the public sector reduces wages and the expectation of increased earnings is lower, there will follow a behavioral response by individuals which will magnify the effects of the lower wages. Similarly, reduced profitability in the market will lead to lower entrepreneurship. Yet the reduction in wages and entrepreneurship must first be initiated by the ELR program for a non-behavioral reason, and the effects of these two behavioral assumptions do not seem to be very large. Both require a significant flattening of wages and profits to be noticeable, and are highly defensible assumptions that still allow for most "altruism" behavior by individuals. The two behavioral assumptions were kept in the model because they are price responses in the market, rather than effort-responses.

Each period in the simulation, the order of agents is randomized, and every agent is selected and given a turn to assess his situation and improve upon it, before reporting his situation for the end of cycle statistics.

Individuals

Individuals assess their employment situation and go on the job market if they are unemployed. Individuals have a reservation wage $\tilde{W_{ij}}$ which is a function of the last wage they received ($\tilde{W_{w_l}} > 0$) if previously employed, the cost of living ($\tilde{W_{P_a}} > 0$) and the amount of time they have been unsuccessfully waiting on the job market ($\tilde{W_t} < 0$).

$$\tilde{W_{ij}}(W_l, P_a, t)$$

The cycle after the Individual puts himself on the market, he begins checking to see whether there are bids above his reservation wage. If there are bids higher than the Individual's reservation wage made on his labor, Individual i will take the highest of them W_i^h. Once the Individual accepts the job offer, the accepted wage W_i^h becomes the worker's wage W_{ij} at the firm F_j which made the offer.

A worker may open a business, if the expected profit is greater than the current wage by a factor. The Individual determines this by comparing the average wage W_a to his own wage $\tilde{W_{ij}}$. Only an Individual with a certain level of productivity $\gamma_i > \mu$ is capable of opening a business.

$$\tilde{V_{ij}}(W_a, \gamma_i, \tilde{W_{ij}})$$

Individuals shop at a stochastically chosen firm, out of the cheapest firms the Individual can find. The Individual sees only a subsection αF of the marketplace, where $\alpha < 1$, representing incomplete information. Firms each have a price P_j, Individuals have a price function S, which is a function of their wage, the percentage of the market they can see and an error factor, $S(\tilde{W_{ij}}, P_j, \alpha, \epsilon)$. The wealthiest Individuals choose from among the higher priced firms, representing either the purchase of luxury versions of goods, or of the inflation of high priced neighborhoods. The rest of the Individuals shop at one of the cheapest firms. Imperfect information and other factors such as location enter in the stochastic factors α and ϵ.

Individuals purchase as many of the product from the selected firm as they are able, given their wage or savings, and save the remainder. The number of products they buy each period determines their standard of living (SOL). The poverty line is defined as the ability to purchase one product.

Private Firms

Each period, firms with profit make bids on available workers. Firms determine the potential value of the worker, by weighting the average value of their employees by the productivity of the worker in question.

$$W_{ji}^{max}(\frac{\pi_{jt-1}}{N_j}, \gamma_i)$$

The firm will bid a fraction of this value, $W_{ji}^{bid} = \beta W_{ji}^{max}$ where $\beta < 1$, unless other firms have already bid higher than this amount. If the highest bid W_i^h for Individual i is greater than βW_{ji} but less than W_{ji}^{max}, firm j will bid an incremental fraction q higher than the highest current bid. Firm j will continue to bid up workers each period until it successfully hires the workers required, so long as $W_i^h + q <= W_{ji}^{max}$. If the Individual i accepts a firm's bid W_{ji}^{bid}, it becomes the Individual's wage $\tilde{W}_{ij}$.

Firms bid on job seekers in the order of highest to lowest value. Profit determines the available funds for expansion, and high valued workers are bid on, until the amount bid matches the available expansion funds.

When a firm incurs losses for r consecutive cycles, the firm must lay off workers. Workers are discharged starting with the lowest worth employee, where the worth is determined by subtracting marginal cost from marginal value, $W_j^{max} i - \tilde{W}_{ij}$.

The pricing strategy uses a modifed version of Basu and Prior (1997), a simple learning algorthm with logic similar to Bayesian updating. Each private firm uses a genetic algorithm learning classifies system (GALCS) to set product prices. A private firm determines four trends each cycle: (a) whether product price has been recently increasing or decreasing, (b) whether sales have been recently increasing or decreasing, (c) whether profits have been recently increasing or decreasing, and (d) whether prices are higher or lower that the industry average. Based on answers to (a) through (d), the firm finds itself in one of 16 states. The GALCS assign a probability vector $(p(D), p(I), p(C))$ to each state. Each state begins with a probability vector $(p(D), p(I), p(C))$ set to the default $(0.4, 0.3, 0.3)$ where

$p(D)$ = the probability that the firm will decrease a given price.

$p(I)$ = the probability the firm will increase the price.

$p(C)$ = the probability the firm will keep the price constant.

When profit is higher than the previous cycle, the action which produced the higher profit (increasing, decreasing or keeping price constant) is increased in probability in the vector.

If the firm incurs loss for a certain number of cycles θ_j, which is a function of the firm's capital, $\theta_j(K_j)$, it fails and the agent exits.

Government and Bureaus

Public employment is represented by Bureaus, which act according to policy, rather than by learning and profit maximization. Each period, government instructs the Bureaus to hire and fire, on the basis of the policy φ, responsive or not responsive, and the extent of public employment λ.

If the policy φ is non-responsive, then λ is the percentage of the workforce which the government should aim to keep publicly employed. Let $\bar{\lambda}$ be the percent actually employed at time t. If $n(\lambda - \bar{\lambda})$ is positive, the Bureaus are instructed to make bids on workers until $n\lambda = n\bar{\lambda}$. If negative, the Bureaus are instructed to fire $n(\bar{\lambda} - \lambda)$.

If the policy φ is responsive, then λ is the percentage of the workforce which the government should allow to be unemployed. Let $\bar{\lambda}$ be the percent actually unemployed at time t. If $n(\lambda - \bar{\lambda})$ is negative, the Bureaus are instructed to make bids on workers until $n\lambda = n\bar{\lambda}$. If positive, the Bureaus are instructed to fire $n(\bar{\lambda} - \lambda)$.

Government sets the tax rate using a learning algorthm similar to the Firm's learning algorthm, but with only one state. The tax rate is reduced when the wage costs are below the total revenue, including the revenue from the Bureaus and the taxes collected from the private sector. When the total revenue is insufficient, the government adjusts the tax rate using the algorthm, attempting to maximize revenue. Results are shown primarily with a progressive tax rate, although a flat tax rate was also introduced. All wages below the public sector wage rate were untaxed. This was to ensure the best chance for redistribution to help the poor.

Results were analyzed for robustness to the the major parameters and simplifying assumptions[2].

[2]For example, the functions for $\tilde{W_{ij}}$ and $\tilde{V_i}j$, and the distributions for the initial endowments were altered, and the results did not differ substantially.

Results

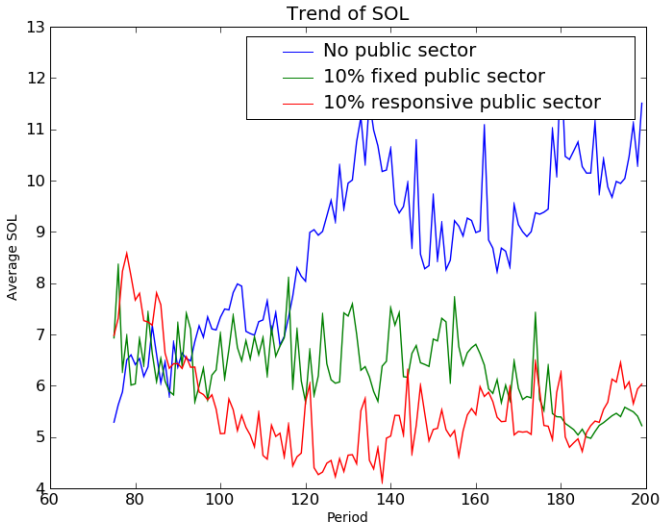
Proposition 1 *Public sector employment lowers the median wage and standard of living, and may even hurt the bottom quintile.*

As seen in Table 1, public sector employment reduces the median wage and the median wage and standard of living of even the bottom quintile. Competition by public sector firms in both the labor market and the product market harms the ability of the private sector to offer higher wages. While the responsive program was able to grow as large as necessary to reduce unemployment, the fixed size program harmed the private sector without any beneficial effect on the economy. The largest sized public sector programs actually drove much of the bottom quintile into poverty, with a median standard of living of 84% of the poverty line.

Table 1: Unemployment and Wages

Policy % Public	Real % Public	Unemployment	Median Wage	Median Wage of 1st Quintile	SOL of 1st Quintile
Table 1: Fixed Level Program					
0	0	10%	56.32	20.26	2.29
5%	10.55%	13%	34.75	12.42	1.30
10%	15.19%	13%	36.68	13.42	1.39
20%	24.46%	14%	29.51	9.32	1.24
35%	39.81%	17%	16.92	5.64	0.84
Table 1: Responsive Program					
5	40.85%	13%	23.76	9.65	1.53
10%	50.66%	9%	16	6.77	1.67
20%	64.62%	5%	14.05	7.35	1.01
35%	67.36%	5%	12.95	6.69	0.84

Figure 1: Effect of Public Employment on Average Standard of Living



Proposition 2 *A responsive ELR program is able to reduce unemployment but a fixed size public sector actually exacerbates unemployment.*

The fixed size public sector caused increased unemployment, in part due to the higher tax rate required to support it. But this was not the only factor. The responsive program required the same tax rate, but reduced unemployment. The difference was that the responsive program kept growing to soak up the unemployed, driving wages even lower in the private sector.

Figure 2: Effect of Public Employment on Unemployment, Fixed Program

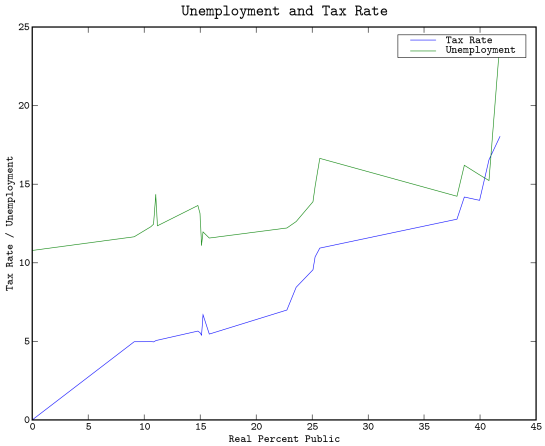
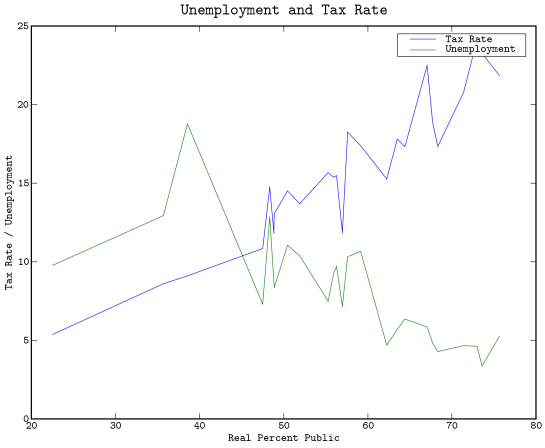


Figure 3: Effect of Public Employment on Unemployment, Responsive



Proposition 3 *As the public sector grows the higher tax rate is less able to collect the necessary revenue to fund the program. The revenue maximizing tax rate is only 10-15*

The public sector could not grow indefinitely without affecting revenues collected (Table 12). The size of public sector that maximized revenue seemed to be 10% for a progressive tax and 10 or 15% for a flat tax.

Table 2: A Sample of Tax Rate and Revenue Collection with a Fixed Size ELR Program

% Public	Progressive	Flat	Cost
0	2670	1516	0
5	11367	7308	2500
10	17104	12719	5000
15	11613	14893	7500
20	7394	8191	10000
25	3238	5188	12500
30	3140	2972	15000
40	2272	2183	20000
50	3434	3001	25000

Discussion

Although a non-zero ELR program appeared to have some beneficial effects when the program was responsive, it was not costless. Unemployment was reduced with a large enough program, when the policy was responsive to unemployment rates, but wages were dragged down, even for the bottom quintile. The non-responsive program reduced wages and created unemployment, by directly crowding out private investment. The responsive program was able to reduce unemployment, but at the expense of wages across the entire economy.

This is interesting. The lowest quintile without the program had wages of about the public sector wage - the median wage of that quintile was a bit below the public sector wages rate for most simulations. The bottom quintile without the program is composed of people who are the supposed beneficiaries of the program - those earning less than the program pays, and those without work. Yet the median wage of the bottom quintile of the simulations which had a program was lower. This result cannot be due to a direct taxation effect, because the progressive (and even the flat tax) tax structure exempts anyone earning less than the public sector wage.

Lower wages result in lower tax revenue given that it is a percentage of the wage that is taken in taxes (whether the tax is flat or progressive). The Laffer Curve suggests that raising taxes will not always increase revenue because of the disincentive to work caused by higher tax rates; this model finds that the size of the public sector and correspondingly higher tax rates together will cause a decrease in revenues, even without considering all incentive effects. This is likely due to the crowding out of private sector firms, which causes the average wage rate to drop and hence produces lower tax revenues.

A large public sector means a large set of bids at the public sector wage rate. Other firms were unable to hire low productivity workers cheaply, and made fewer bids on high productivity workers. With fewer bids to drive up the rate for each worker, even high productivity workers must end up choosing a job at a lower rate. This seemed to have an effect of flattening out wages in the market that retained a large public sector.

Higher taxation means that the net wages will be lower. Competition in the product market also cost private firms profit. Less profit led to lay-offs and reduced expansion for profitable firms. Fewer firms hiring once again depresses wages. These same effects may cause an increase in unemployment, as seen with a fixed size employment program.

Although the public sector looks large in these results, it should be noted that most modern industrial states already have public employment of at least 10-20% (see Figure 3). All public sector employment may not conform to the assumptions of the public sector in the model. However, modern states also retain social welfare programs, which do reflect more of these assumptions, even if they are not pursuing active employment policies (see Table 3). Therefore, the rates of public employment in the model which maximize welfare of the poor and tax revenue may reflect sizes

than currently exist in some of these countries.

Figure 4: Share of Public Employment in OECD countries

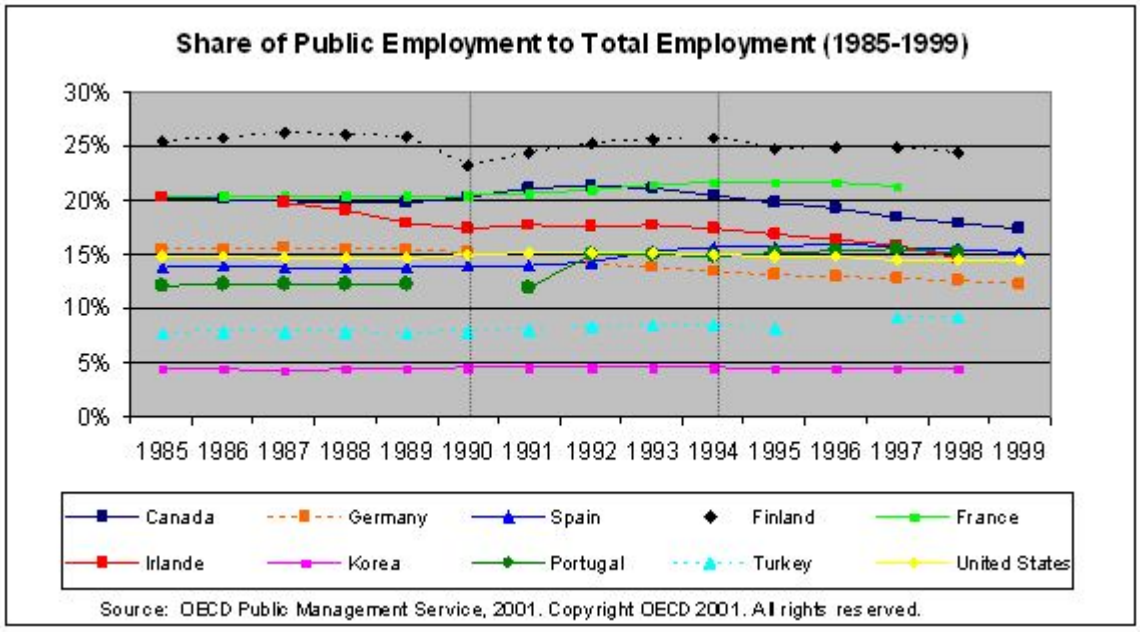


Table 3: A Sample of Social Assistance Spending and Unionization

Country	SOCX	WCOORD	GDPC
Sweden	29.99	4	19770
Denmark	26.99	5	20948
Netherlands	26.92	3	17606
Belgium	25.94	5	16987
Austria	24.10	4	17403
Germany	23.95	4	19011
France	23.09	2	17125
Italy	21.62	2	18914
United Kingdom	21.10	1	16377
Norway	19.10	5	19942
Canada	17.39	1	21719
Switzerland	14.20	5	22413
Australia	13.26	4	18386
United States	12.96	1	24179

Notes: SOCX is the percent of GDP of social welfare spending; WCOORD is an index of wage coordination, with 1 as the least and 5 the most coordinated; GDPC is GDP per capita in constant US dollars. Data from the Luxembourg Income Study Welfare Database.

Conclusion

Results from this model are preliminary, but interesting. The agent-based modeling approach provides unique insights into the dynamic of the labor market, and the potential consequences of government intervention. Heterogeneous actors with limited information interacting in an evolutionary environment, with learning and without the assumptions of perfect competition or equilibrium, allow for emergence of both market failure and also unexpected consequences of policy – government failure.

Results from the model suggests that in fact government employment does crowd out private employment, and is unable to perform an efficient transfer of income, even

assuming altruistic workers and efficient public administration. Given the negative outcome with these generous assumptions, it appears that coordination in the market, and natural selection of firms directed to profit-maximization may be an important factor distinguishing the more prosperous market system from the reduced prosperity found in systems with large public sectors.

Acknowledgments

I am indebted to Thomas Moore of Inductive Systems and Alexander Volokh for help with model design, Robert Axtell for encouragement, and Karen Campbell and Michael Makowsky for paper preparation. All remaining errors are my own.

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