Supplementary files are available for this work. For more information about accessing these files, follow the link from the Table of Contents to "Reading the Supplementary Files".

THE ECONOMICS OF A BITING MINIMUM WAGE

L.V. Petrides[Θ] and B.C. Dangerfield[Π]
Centre for O.R. and Applied Statistics
University of Salford
Salford M5 4WT
UK

Abstract: *Conventional wisdom as regards the effects of a biting Minimum Wage (MW) is challenged in this paper through the findings of a System Dynamics model. Given a number of different plausible assumptions, a number of counter intuitive results are found to emerge such as a longer term permanent increase in employment levels, a greater total number of businesses in the economy associated with lower total employment levels than originally, and a trade-off in the well being and the employment levels between those firms whose cost structure was affected by the MW and the unaffected firms. Finally, two variables that are normally considered to be irrelevant to the investigation of the economic effects of a biting MW, namely consumption spending and fixed costs per business, come to the forefront of the analysis.*

Keywords: *minimum wage; economics; system dynamics; simulation*

1. INTRODUCTION

One of the most politically sensitive issues whose economic effects remain largely unclear, is that of the Minimum Wage (MW)[1]. The conventional and very little challenged – until recently – view of economists is based on a neoclassical model according to which there can be only one result from the imposition of a MW: a reduction in employment. As Dickens et al (1994) argue:

"*Too often in past work, the only theoretical models used are competitive ones in which the only empirical question is not 'do minimum wages reduce employment?' but 'how much?'* "

It was mainly after the empirical findings of Card and Krueger (1994) for the US and Machin and Manning (1994) for the UK that doubt was cast with regard to the validity of the traditional approach. The alternative theory consequently put forward, that of monopsonistic labour markets,

[Θ] E-mail address: lpetrides@cwcom.net
[Π] E-mail address: B.C.Dangerfield@salford.ac.uk
[1] A MW imposition is not differentiated from a MW increase in this paper as, ultimately, both result (if the levels of the MW are high enough) to an increase in wage rates. The two nouns will be consequently used interchangeably throughout.

was based on a slight variation of the conventional neoclassical model, with firms possessing some influential power instead of being completely unable to affect wage rates. This assumption proves strong enough to allow for increased employment levels within an economy, provided that the MW does not exceed a certain undefined upper limit.

Since both of these approaches adhere to the principles of the neoclassical paradigm however, attention has inadvertently focused on certain areas associated with MW, and not on others. While business costs and the demand and supply of labour for example stand at the very core of the neoclassical models, key variables and processes such as spending or the possibility of firms entering/exiting industries, are usually left completely uncontemplated with. What's more, given the static nature of the aforementioned models, questions regarding the dynamic behaviour of any variables that might arise due to the introduction of a MW become meaningless. As a result, the scheme has come to be considered as either immediately beneficial or detrimental for an economy making it impossible to distinguish between different short-term and longer-term effects. As will be demonstrated below though, by adopting an approach that is markedly different to the neoclassical one, surprising and counter intuitive findings emerge which, according to the authors' opinion, go some way into bringing new insights as regards the economic effects of a biting MW.

2. A SYSTEM DYNAMICS MODEL

In an attempt to further our understanding of the economics of a biting MW, an altogether different line of attack to the one associated with the neoclassical paradigm is adopted introducing causality, disequilibrium, imperfect information, and endogenous dynamic behaviour into the analysis. A generic System Dynamics (SD) model is built and described below and its results prove to challenge current economic wisdom

2.1 Model structure and causal hypotheses

2.1.1 Identification of main sectors

The model is comprised of two main sectors to capture the fact that a MW scheme would increase wages paid only in a certain proportion, (1-a), of total firms in an economy, the *affected* firms. The proportion of *unaffected* firms in the economy is consequently described by (a). As will be shown later on, the greater the proportion of the unaffected firms within the economy, the greater the possibility for the products produced

within the unaffected sector to be good substitutes for the ones produced within the affected sector, and the less the need to resort to imported products will be in the event of price hikes.

For added realism and in order to allow for a more appropriate treatment of the differences found between the manufacturing and service firms, the affected sector gets analysed further into firms dealing with (manufacturing) goods on the one hand, and services on the other. The proportion of the affected manufacturing firms[2] in the economy is consequently considered to equal (b), with (1-b) describing the proportion of firms within the affected service sector[3]. An analogous treatment for the unaffected firms was not considered necessary especially after it became evident that the two sub-sectors of the affected firms behaved very similarly (as expected).

Figure 1 summarizes the hypothetical distribution of firms in the simulated economy.

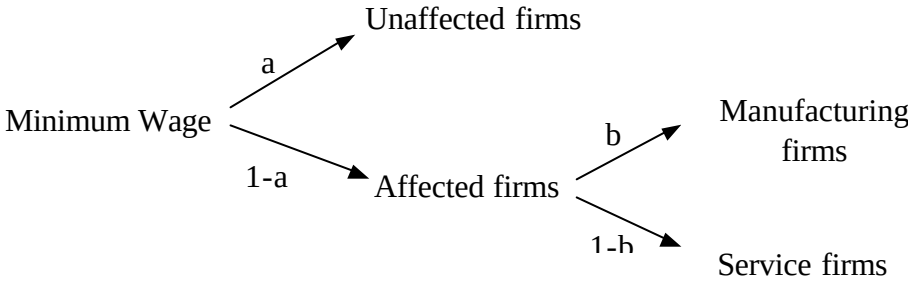

Figure 1 The distribution of firms

2.1.2 Consumption and identification of consumer groups

Consumption is initially spread among the different sectors according to the way firms are distributed within the economy. As prices in different sectors vary however, consumption will be diverting away from the relatively pricier products to the better valued ones (see analysis in following sections, esp. section 2.1.5).

Figure 2 shows in an aggregate manner the causal relationships that are associated with consumption in the model.

[2] Whenever there is any mentioning of "service" or "manufacturing" sectors, it should be understood that reference is made to the relevant sector within the larger category of the *affected* firms sector. The unaffected sector on the other hand will be addressed as such.

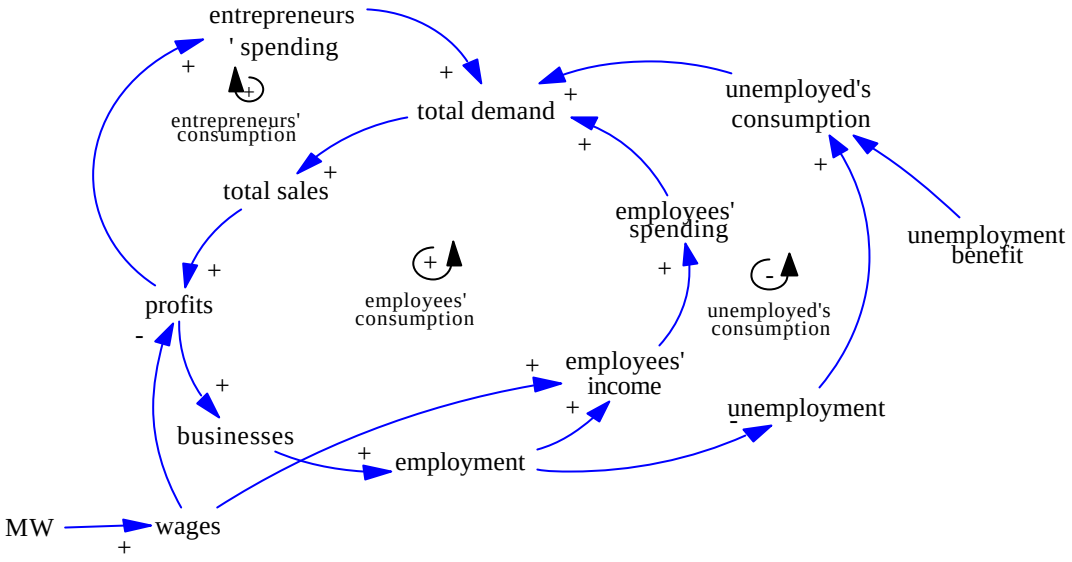

Figure 2 Influence diagram describing consumption

After a biting *MW* is introduced, an increase in *wages*[3] occurs which acts to boost *employees' income.* Assuming that employees will eventually spend all of their income, *employees' spending* will rise, leading to an increase in s*ales*. At the same time that employees are increasing their consumption however, a reduction in *profits* due to the higher *wages* that must now be paid out takes place, reducing *entrepreneurs' spending* and consequently influencing *total demand* and *sales* adversely. Since the reduction in *profits* is of equal magnitude to the increase in *wages*, *total demand* and *sales* should be expected to remain unaltered from this process.

A reduction in *profits* however can also be expected to drive some firms out of business reducing *employment* and naturally *employees' income* as well. A drop in the latter variable acts, as already noted, to reduce *sales* which, in turn, reduce *profits* further, causing more businesses to shut down and so on. In an attempt to break free from this vicious cycle, the government is assumed to pay out unemployment benefits thereby creating a controlling (negative feedback) loop by ensuring a minimum level of consumption for the unemployed. As the number of the unemployed rises therefore, more people are getting paid unemployment benefits, *consumption* from the unemployed rises and *total demand* and consequently *sales* increase hopefully containing the crisis or even reversing the negative trend.

[3] The possibility of an increase in productivity due to the MW is also considered later on. If productivity increased because of the MW, profits need not reduce due to an increase in wage rates in the longer term.

There are of course not only three different consumption groups in the model as suggested in the aggregate influence diagram above, but seven, since consumers are identified separately according to the sector they work in (manufacturing firms, service firms, or unaffected firms) and their status (entrepreneurs or employees), with the unemployed naturally standing in a separate category -see Table 1.

Table 1. Consumer groups

Categories of consumers	(Affected) ***m***anufacturing firms	(Affected) ***s***ervice firms	***U***naffected firms
Entrepreneurs	m_entr	s_entr	u_entr
Employees	m_emp	s_emp	u_emp
Unemployed	unemp		

Consumption spending is consequently defined separately for each of those groups according to their income, which is in turn determined from profits in the case of entrepreneurs, wages in the case of employees, and a constant exogenous minimum monthly income rate representing the unemployment benefit in the case of the unemployed (see further analysis).

2.1.3 Service sector

Figure 3 presents the main causal relationships within the service sector:

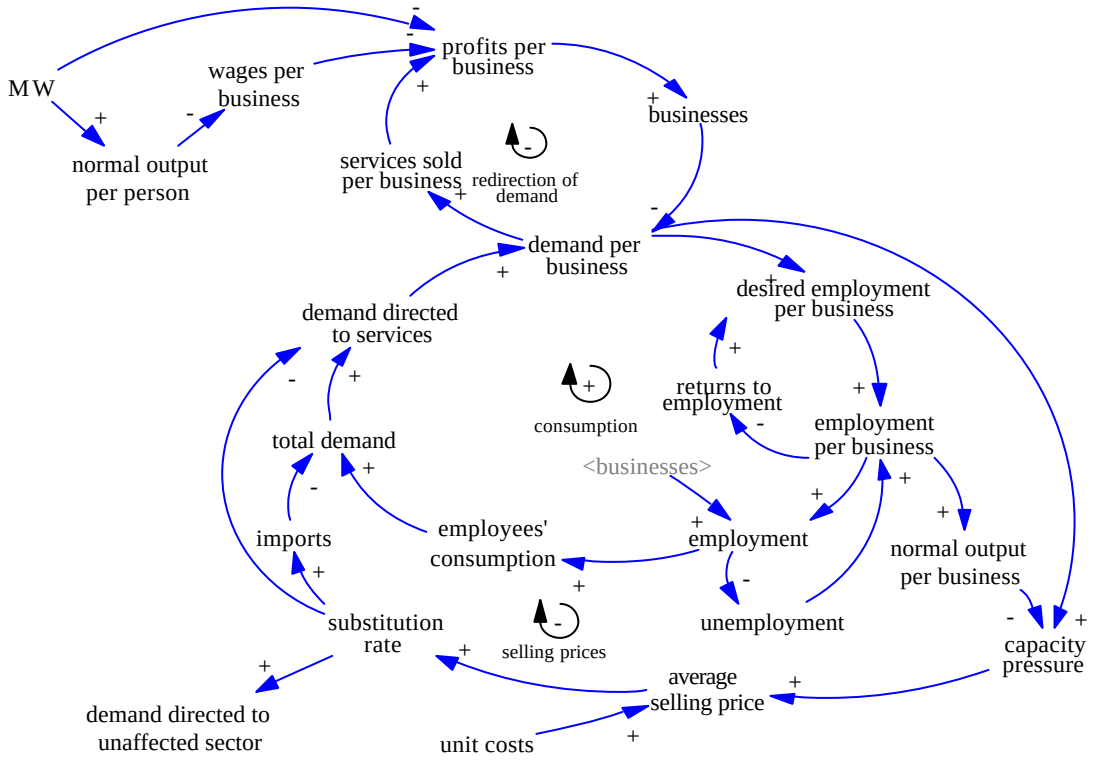

Figure 3 Main causal structure of the service sector

One of the consequences of the *minimum wage* if *normal output per person* remains constant is, as already suggested, the reduction in *profits per business* and the consequent reduction in the number of *businesses* in operation. With a reduced number of *businesses* however and an unchanged demand, existing firms will be faced with increased demand (*demand per business*) and *services sold per* (existing) *businesses* can be expected to increase if output can rise. Since productivity in the short run is at least partially determined by demand conditions, it is assumed that a short-term increase in output (within limits of course) will be attainable and a redirection of demand (from the closed to the remaining firms) will take place closing the (negative feedback) loop, although as will be demonstrated later on this assumption will be challenged.

With boosted *demand per business, desired employment per business* will increase in an attempt to secure a permanently greater supply of services and, if no constraints exist, actual *employment per business* will follow suit boosting *employment* levels in the economy and thereby mediating the adverse *employment* effects due to the closure of *businesses*. If *employment* levels within the simulated economy ultimately reduce, *employees' consumption* will naturally drop and the *demand directed to services* will fall reducing *services sold per business* thereby creating a positive feedback loop associated with employment levels and consumption.

Employment per business of course cannot be expected to increase ad infinitum since at some point or another diminishing[4] *returns* will kick in making it unprofitable to keep hiring personnel. *Desired employment* at that point will start reducing, limiting *employment per business* and therefore *normal output per business*. If supply cannot match demand however, *capacity pressure*s will emerge and the selling prices (*average selling price*) will eventually rise causing consumers to substitute (*substitution rate*) away from the service sector into imported products (*imports*), in which case *total* (domestic) *demand* falls, or to products produced within the unaffected sector (*demand directed to unaffected sector*) naturally reducing the *demand directed to services*. A controlling selling price loop therefore emerges regulating demand according to supply.

Unemployment, or the lack of it to be precise, is, as shown in Figure 3, another key factor that limits *employment per business*, and it is also

[4] The negative loop will be activated due to increasing returns in the case of a drop in employment levels per business.

assumed to restrict the opening up of new businesses (latter link not shown). When the economy is booming and unemployment approaches its natural rate then, it is considered to become exceedingly difficult for firms to fill their vacancies and prospective entrepreneurs are also thought to be put off from going at it on their own due to finding difficulties in spotting and employing appropriate personnel. Discrepancies between output and demand again arise and the selling price loop is again activated to constrain demand. An expansion of the model to include a pressure to increase wages in such circumstances could have been included but this was considered to increase the model's boundary unnecessarily and at the expense of its intended objective.

Apart from differences arising due to mismatches in demand and supply however, *selling prices* can also vary with *unit cost* alterations that may occur because of the MW. Different scenarios are consequently explored with firms either assumed to be passing on their increased costs in terms of higher prices or refraining themselves from doing so.

Finally it should be added that the possibility of a MW acting as a stimulus to management for adopting more productive ways of operating as suggested in Nolan (1986 esp. p.84) and Edwards and Gilman (1998 p.11) has also been contemplated with[5]. The positive link between *MW* and *normal output per person* therefore suggests that a MW may actually act to increase normal productivity reducing the number of employees required to achieve a given level of output thereby potentially reducing employment per business (relationship not shown). If employees per business reduced however, *wages per business* would fall and *profits* would naturally increase.

2.1.4 Manufacturing sector

The principal reason for splitting the affected sector into manufacturing and service firms is to account for the fact that manufacturing firms can (and for the most part do) hold inventories of their products creating a time buffer between the supply and demand. The influence diagram describing the main causal structure of the manufacturing sector therefore is a slightly augmented version of its service counterpart including the required inventory related variables and their interconnections – Fig. 4.

[5] Many thanks are due to John Dobson from the Management School of the University of Salford for highlighting this important link, and for providing us with many helpful references supporting this (and a number of other) point(s).

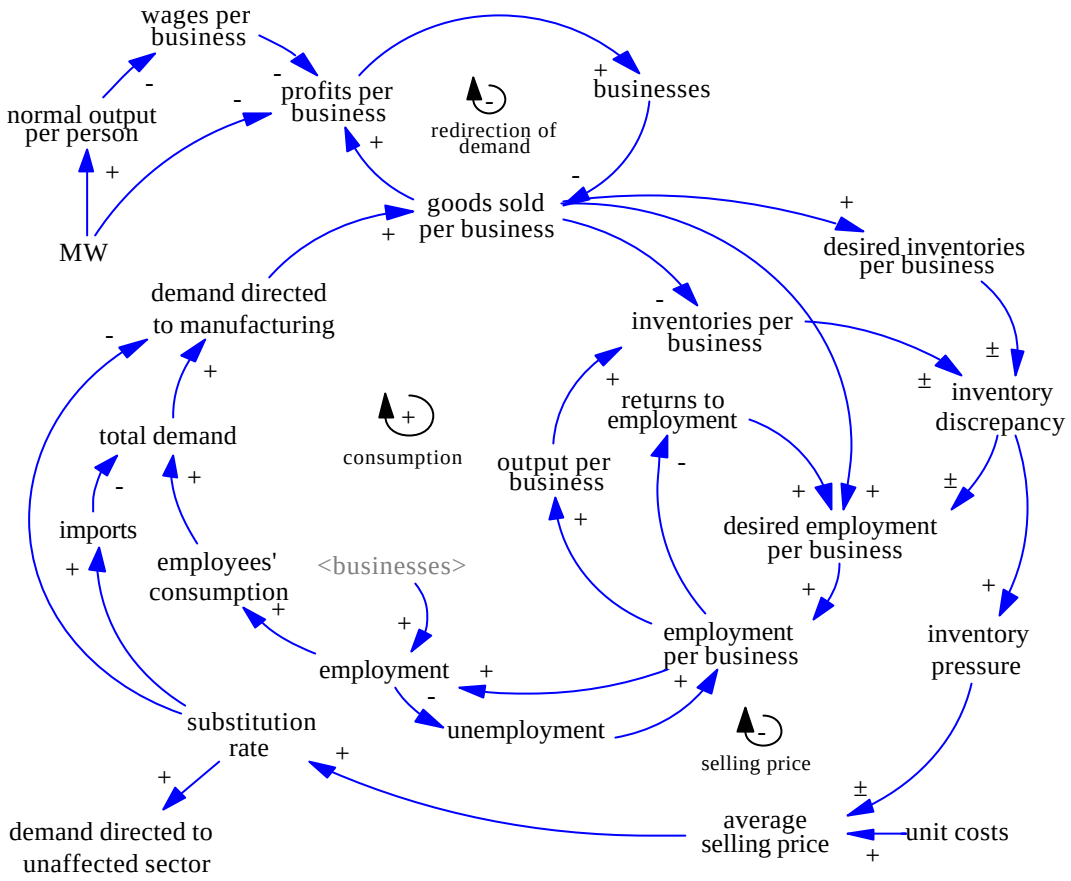

Figure 4 Main causal structure of the manufacturing sector

An increase in the number of *goods sold per business* in this sector apart from causing *desired employment* to rise also acts to create *inventory discrepancies* by reducing actual *inventories per business* and increasing their *desired* levels. A *discrepancy* between actual and desired inventory levels though gives rise to *inventory pressures* which are then translated in *selling price* changes[6] in an attempt to regulate demand and to eventually restore equilibrium between actual and desired inventories.

As could be imagined however, *inventory discrepancies* can also be eliminated through adjustments in *employment per business*[7]. If *desired inventories* are greater than actual *inventory* levels then, *employment per business* will increase boosting supply and building *inventories* back up eliminating *inventory discrepancies*.

[6] The plus or minus signs in the influence diagram in Figure 4 provide a short cut in indicating that discrepancies between the desired and actual states of inventories may arise both due to actual inventories levels being higher than their desired levels and the other way around. In the former case, the greater the *discrepancy*, the less *desired employment* will be and increases in *inventory pressure* will serve to reduce *selling prices*. If desired inventories are greater than their actual levels though, *desired employment* will increase and inventory pressure will drive *prices* up.

2.1.5 Unaffected sector

Since prices and profits within the unaffected sector remain unaffected from the cost implications of the MW much of the detail that was deemed necessary for the proper representation of the affected sector was here considered irrelevant and was consequently omitted. The considerably more aggregate causal structure of this sector is depicted in Figure 5.

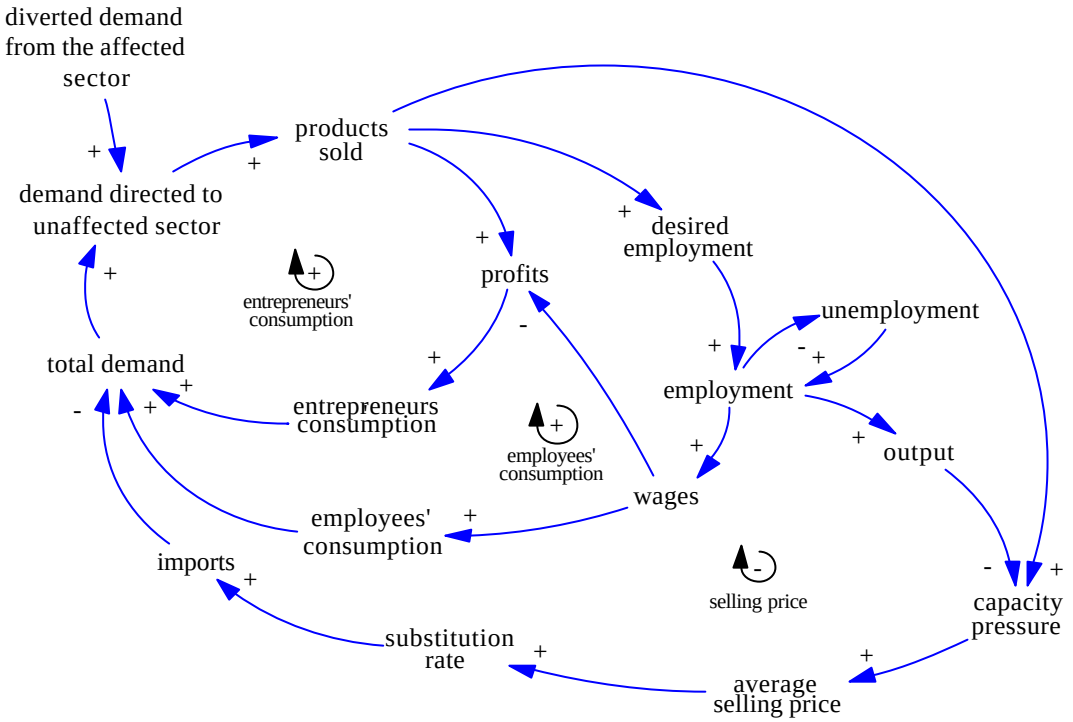

Figure 5 Main causal structure of the unaffected sector

The most important difference between the causal structure of this sector and the ones described previously is, as suggested from a careful look in Figure 5, the aggregation of all businesses in a non-differentiated entity preventing the 'average business' to be the basic unit of analysis. Profits, sales, and employment therefore are all considered from an aggregate perspective.

Positive consumption feedback loops can again be identified, where increases in *demand* boost sales (*products sold*), *profits*, *entrepreneurs' consumption*, *total demand* and therefore the *demand directed to the unaffected sector* closing the loop, while if *employment* needs to increase *profits* will drop yet *employees' income* and *employees' consumption* will rise driving *total demand* and the demand directed to the unaffected sector higher.

As ever, a reduction in *unemployment* will again contain *employment* restricting *output* thereby creating *capacity pressures* that activate the (controlling) selling price loop which regulates demand through increases in imports. Other employment restrictions however are assumed away.

2.1.6 Further assumptions: initial conditions, constants, and table functions.

In any simulation it is impossible to begin unless numerical values are assigned to variables. For the purposes of this generic model therefore the affected and unaffected sectors are of equal proportion (i.e. a=0.5), and the same holds true for the proportion of manufacturing and service firms within the affected sector (i.e. b=0.5). If 'a' is chosen to equal less than 0.5, price increases in the affected sector will divert demand outside the domestic economy more aggressively since it is assumed that the unaffected sector's product range will be limited restricting the number of substitute products produced within the domestic economy whose prices remain unaffected from the MW. The need to reside to imported products in such cases therefore increases. Figure 6 illustrates the relationship.

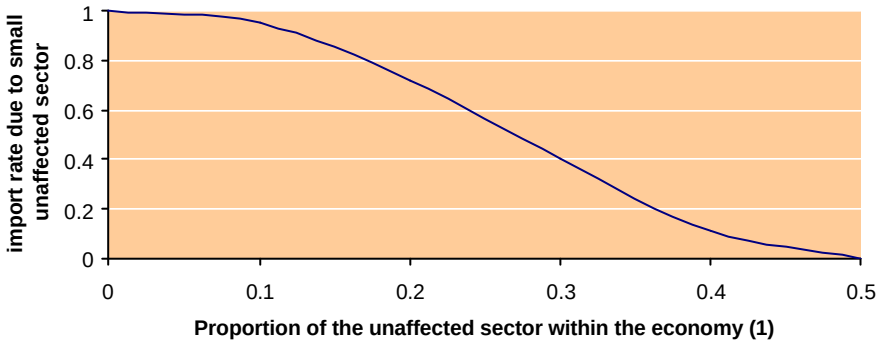

Figure 6 Import rate as determined from the proportion of the unaffected sector within the economy in the face of price increases within the affected sector

Total labour force equals 10 million people and with an average of 10 employees per firm and a 10% initial unemployment rate, the number of firms in the affected sector total approximately 409,000 ensuring that employment is equally divided between the two main (affected and unaffected) sectors.

As previously suggested restrictions as to the minimum and maximum average number of employees per (affected) firm also apply, the minimum limit being 8 persons and the maximum 12 persons per firm. Naturally, if these limits are ever to be reached the process will be gradual and imprecise since the basic unit of analysis is comprised of average and not individual "units" as is the case with most traditional

neoclassical models (where "units" stand for firms, profits, wages or what have you). For that reason a fuzzy table function – see Sterman (2000 pp.529-532), or Kosko (1994) for a general introduction into fuzzy thinking – presented in Figure 7 has been adopted to simulate the process properly.

Figure 7 Determination of the effect on desired employment

The *effect on desired employment* that ultimately determines *desired employment* does not allow the latter variable (desired employment) to reduce below an average of 8 or exceed an average of 12 persons per (average) firm.

The average wage rate per person per hour in the affected sector next, equals initially £5, which makes up an average monthly wage rate per person of approximately £870, while average profits per affected businesses equal approximately £3260 per month. With the introduction of a MW, average wage rates in the affected sector increase by 10% initially, and by a further 5% as time elapses to account for the differential pressures that a biting MW could bring along with it. In the unaffected sector on the other hand, the hourly wage rate per person stands at a constant of £10, while total initial business profits equal their total equivalent for the whole of the affected sector, i.e. approximately £1.3e9 per month. The unemployed's minimum monthly income finally comes to merely £520 per person.

Productivity figures must also be provided in order for the simulation to proceed. Average output per person which is thought of as being the same for both sectors within the larger affected-firms category, stands at approximately 205 units per person per month initially, while this figure rises to approximately 390 for the employees in the unaffected sector. Although productivity may vary with the MW as suggested earlier on, it may also vary in the short run according to demand conditions by up to 10% before adjustments in either prices or employment are made.

The normal (initial) average price charged within the affected sector comes to £10 per unit while their unaffected equivalent increases to an average of £14 per unit. As prices in the affected sector increase, the substitution of goods occurs according to the table function produced in Figure 8

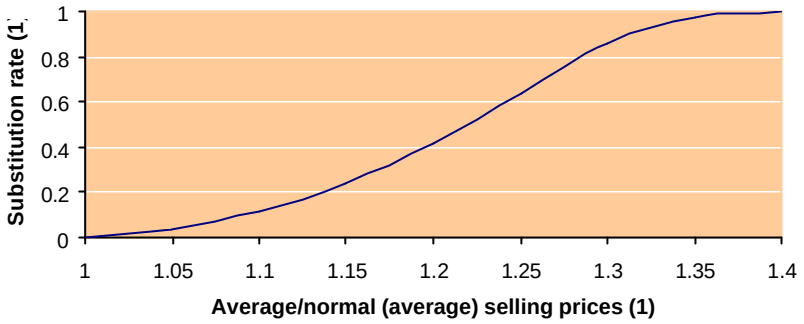

Figure 8 Determination of Substitution rate

The significant difference in the initial prices charged within the affected and the unaffected sectors causes demand to be relatively insensitive to small variations in price. As prices increase further however, consumers will substitute away from the affected sector more aggressively, with a complete substitution occurring in the (highly unlikely) case of the affected sector's prices equalling their unaffected equivalents. A negative substitution rate could also have been allowed to represent a diversion of the unaffected firms' demand into the affected sector in the case of lower than normal selling price levels; as price cuts in products that already sell at low prices are not likely to attract large numbers of extra custom however, and given that quantities exchanged in the unaffected sector will increase due to an income effect[7] anyhow, the substitution rate remains at 0 (zero).

Imports are also determined from the relationship depicted above represented by a constant proportion rate of 10% the substitution rate, although this constant (10%) rate can vary with the initial choice of the size of the unaffected sector as described in the beginning of this section. Hence, assuming that the unaffected sector is at least half the size of the economy if consumers are to redirect £100 of their spending out of the affected sector, £90 will be spent in the unaffected sector and the remaining £10 will go into consumption of imported goods. Naturally,

[7] The income effect is defined as the change in consumers' real income resulting from a change in product prices. The assumption here is that the increase in real income will allow for an increase in quantities exchanged within the affected sector.

increases in the unaffected sector's prices also lead to greater import rates again according to the relationship depicted in Figure 8.

The precise relationship between the desired businesses that will eventually be in operation within the affected sector and profits is illustrated in Figure 9.

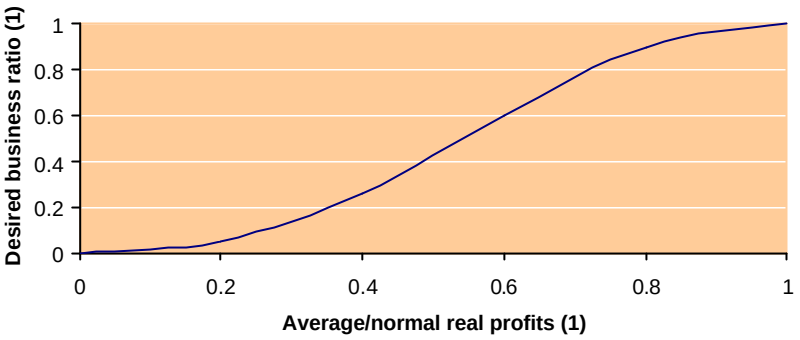

Figure 9 Determination of Desired business ratio

This relationship is again assumed to be sigmoid being flatter near unity since firms are thought to be relatively insensitive to small variations in profits. A further reduction in average profits however, will eventually drive ever more firms out of business, aggravating the drop of the curve.
If profits end up exceeding their normal (initial) levels on the other hand, a linear relationship between the two variables will hold, where for, say, a 10% increase in average real profits, new firms will enter the industries at a rate of 5%, with the basis for the percentage calculation of new firms being the normal (initial) number of businesses.

Finally, tight unemployment conditions, i.e. the effect low unemployment has on employment as suggested in sections 2.1.3-2.1.5, are defined according to the relationship shown below.

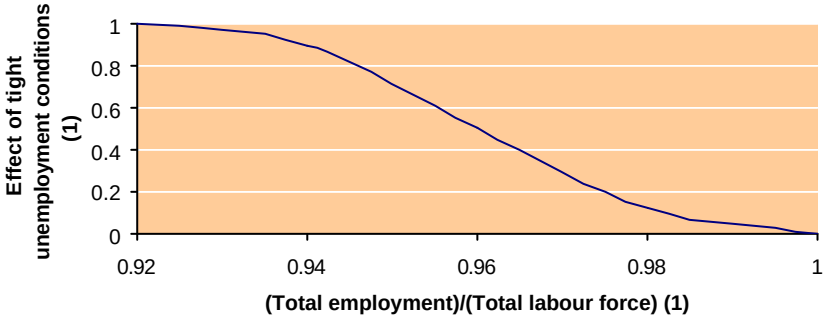

Figure 7 Determination of tight unemployment conditions

Initial unemployment will be remembered stands at 10% the total labour force, with the effect of tight unemployment conditions exerting no influence at those levels. As unemployment drops however, the effects of

its reduction will become more and more evident causing discrepancies between the desired and the actual employment levels and setting barriers for new businesses entering the market.

2.2 A note regarding the chosen constants of the model and parameter estimation in general.

It would be fair to say that this section would have been restricted to a small paragraph if it was not for a reply John Sterman (SD3408) posted in an SD discussion list[8] recently, illuminating implicitly the extent of the problems created by a lack of understanding of non-SD experts as regards the use of, among others, "non-scientifically"-verified parameters in some SD models.

It is of course true that none of the parameters used in this model have been based on "scientific" data cropping out of research. They are all "say" figures that are meant to generally approximate the processes they describe. A number of points regarding this practice associated with this particular model should be made clear here:

Firstly, this model is not meant to be simulating any existing economy. It is a generic model in its nature aimed at enhancing our understanding of the economics of the MW. Had there been an attempt to simulate the effects of a MW in a particular economy, this model would have been further disaggregated into specific industries, and estimates would have been obtained for the model's parameters. It should be perhaps added that SD modelling has, and has had for over 20-25 years[9] now, in its disposal very powerful optimisation techniques[10] that allow for an alternative means of estimating parameter values, even if some "scientific" data are vague, imprecise or, at times, plainly wrong.

Secondly, because of the non-linear nature, the multiple interconnections and feedback loops, and the ultimately limited number of variables and parameters responsible for the behaviour of an SD model, the sensitivity of an SD model's results is greatly reduced to even unrealistic changes in most parameters[11]. This is the reason for the extreme, according to many

[8] One can find information and subscribe to this list by visiting the following web address: http://www.vensim.com/sdmail/sdmail.html

[9] The earliest study known to this author which experimented with optimisation techniques was by Nelson and Krisbergh and it dates back to 1974.

[10] For an explanation of how optimisation works and how it can be put to practice see Dangerfield and Roberts (1996), and Coyle (1996) or (1999).

[11] Forrester (1991 p.27) writes: "One author criticized the Urban Dynamics book on the basis that it contained a very bad model because *the critic* had been unable to find any policy [policy explorations

standards, way sensitivity analysis is usually carried in SD modelling, ie by the doubling and/or halving of parameter values. In this model circumstances are no different. Apart from a few parameters whose identification should certainly be most welcome by policy makers as they highlight those areas that warrant careful attention before such a scheme is introduced, the model's findings are robust despite considerable alterations in parameter values (see section 2.4).

Finally and as a concluding remark, it seems to the authors that methodologies whose models produce results that are highly insensitive to parameter changes should be clearly preferred over their alternatives especially when carrying out economic-related research, given the uncertain, to say the least, accuracy of "scientific" economic measurements. The following example found in Mayer (1993 p.73) should probably convince the reader:

"*…the US trade deficit with Canada in 1982 was either $12.8 or $7.9 billion depending on whether this number came from US or Canadian publications…*"

2.3 Model output and analysis

Given the highly aggregate structure of this model the (transitory) dynamics produced should not be expected to match in great precision the actual (transitory) dynamics that would be experienced within a real economy after a biting MW gets imposed. Saying that of course, it should be added that no method has been devised as yet that enables one to disentangle the effects a MW has in an economy from all other economic influences in order to actually make it possible to determine empirically what those effects really are and contrast them with the model's output.

As regards the presentation of the model's results and the consequent analysis, it should be added that the similarity between the structures of the manufacturing and the service firm sectors allows for an aggregate 'affected firms sector' analysis which will be adopted throughout for simplicity and economy of space.

2.3.1 First run: No extra spending, no permanent productivity gains.

Initially, we will assume that consumers will not spend the extra income they receive in terms of higher wages breaking the link between

include both parameter and structural changes] in the model that substantially changed the behaviour of the model." (emphasis added)

employees' income and *spending* (Fig. 2), and explore what happens in the case of firms not being able to match the increased wages in terms of increased productivity.

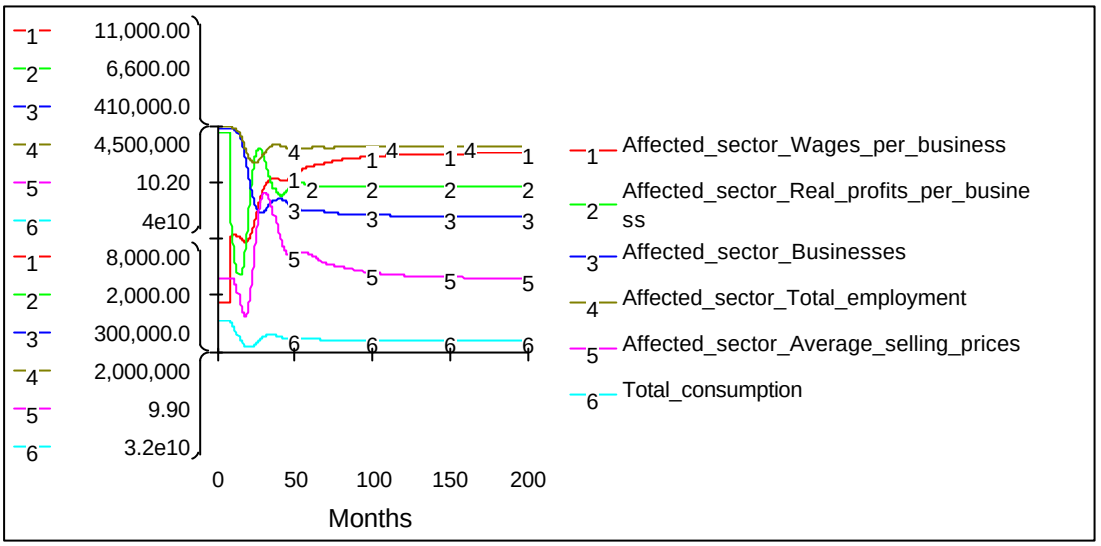

Figure 8 First main run: No extra spending, no permanent increases in productivity. Plot of wages per business, real profits per business, the number of businesses, total employment and average selling prices within the affected sector, and of total overall consumption.

The results of this scenario prove to be quite disheartening (Fig. 8). After the introduction of the MW at the tenth month of the simulation, monthly wage rates increase (not shown explicitly) and businessmen are forced to pay out higher *wages* reducing *profits.* Lowered *profits per business* however cause some *firms* to shut down and *employment* is reduced. With remaining firms assumed to have enough slack capacity initially, almost all of the (excess redirected) demand is met without having to increase *prices*[12] (to adjust demand according to supply) dramatically and an increase in sales and *profits* does follow suit. The permanent reduction in *total consumption* however due to the (remaining) employees' preferences to increase savings rather than eventually spending the extra funds they receive ultimately causes both *profits* and *employment* levels to settle at lower levels than initially.

The situation within the unaffected sector is not much different as evidenced in Figure 9. Despite the unaffected cost structure, the reduction in total consumption causes the *consumption* directed to that sector to fall, and both *profits* and *employment* levels are consequently adversely

[12] The initial reduction in prices is caused due to the reduced total consumption levels. As businesses shut down, supply also gets restricted, and prices end up somewhat higher.

affected. The resulting reduction in *total employment*[13] and *total profit* levels therefore (also) depicted in Figure 9 should not come as a surprise.

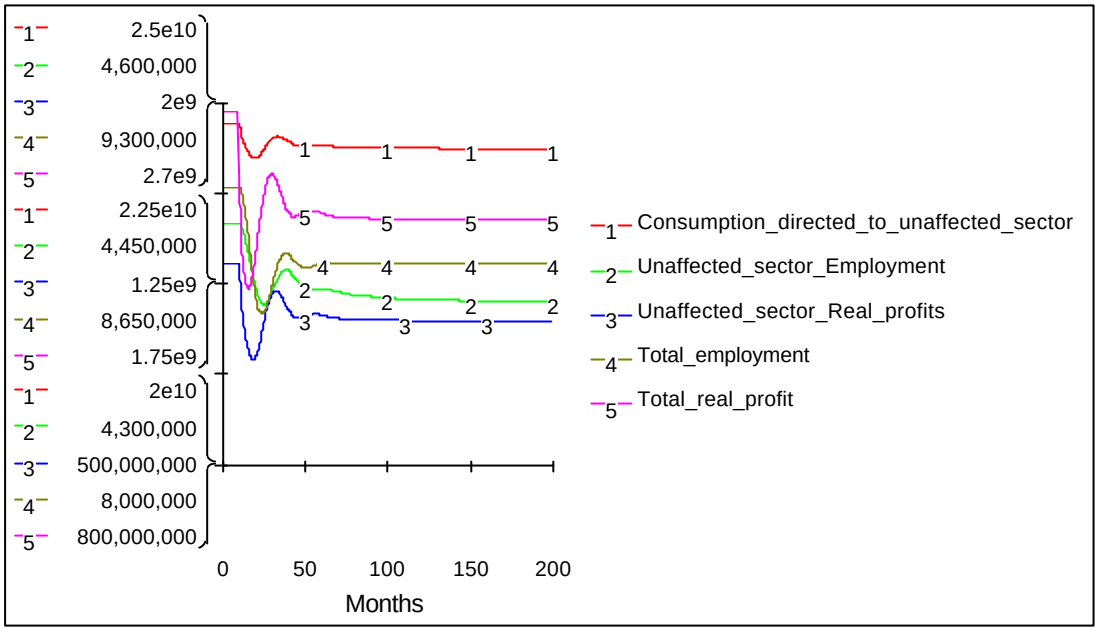

Figure 9 First main run: No extra spending, no permanent increases in productivity. Plot of consumption directed to unaffected sector, unaffected sector's employment and real profits levels and total employment and real profits

Finally, the reasons for the transitory oscillatory behaviour that emerges from this run, which will be considerably more evident in the subsequent reruns, provide some basic understanding into the causes of the herdish behaviour that is generally observed in many real world situations after a sudden crisis or a profitable opportunity emerges. Because of both the (material and information) delays that are involved in the decision making process of opening up or closing down businesses and the bounded and intended rationality of entrepreneurs, too many firms close down after the initial severe reduction in profits leaving only a few ones operating behind which get all the benefits associated with the redirection in demand. As a result these remaining firms eventually see their profits skyrocket. Once it is realized that greater profits than normally are realized by existing firms, too many businesses open back up again in an attempt to benefit from the arisen situation overcrowding the market and causing the whole process to start anew albeit at a lower intensity until, eventually, 'normal' profits are achieved by the 'right' number of businesses.

[13] Figure 2 shows that the consumption from the unemployed acts as a balancing force to total consumption if employment levels divert from their initial levels. The fact that equilibrium is established at lower employment and consumption levels than initially implies therefore that the adverse effect of the employees' new saving habits on total consumption outweighs the increase in consumption that stems from higher spending from the unemployed. The stabilizing role of the unemployment benefits will be further discussed in the next section.

2.3.2 Second run: Increased spending, no permanent productivity gains
Because a MW would generally affect the lower-income employees, it is more likely than not that the additional wages will be eventually spent. In the remaining runs then, adjustments are made to account for this more realistic alternative. In this run in particular, the output of the model in the face of no permanent productivity gains is explored.

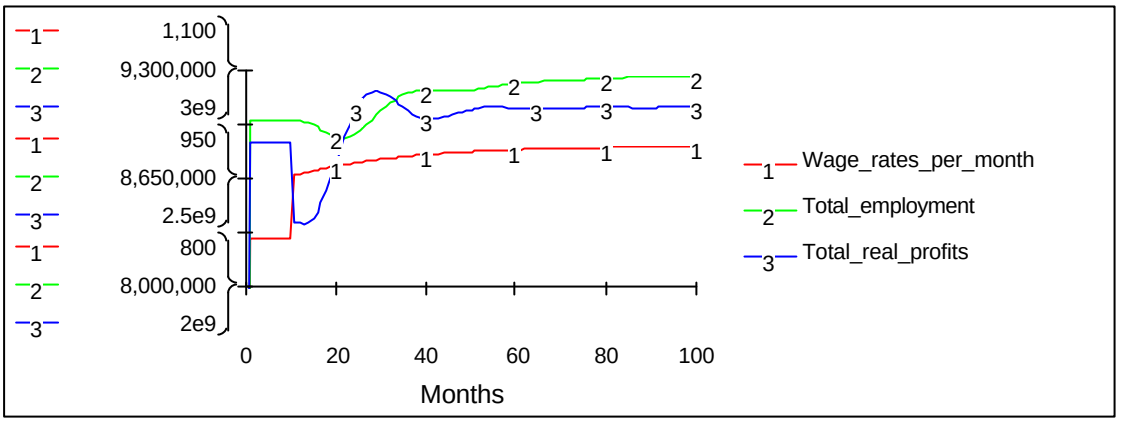

Figure 10 Second main run: Increased spending, no permanent productivity gains. Plot of wage rates per month, total employment and total real profits.

Figure 10 above, illustrates that a biting MW in these circumstances will initially hurt *total employment* and *total real profit* levels, yet, as time elapses a recovery will emerge and equilibrium will ultimately be established at higher levels than originally. In order to best explain the reasons for this kind of behaviour we will slightly divert from the main analysis of the MW, revisit the model's structure, and carry a number of partial model tests.

As highlighted in section 2.1.2, the introduction of a biting MW if no closures of businesses occurred would not be expected to affect total consumption. This is indeed the case as demonstrated by *total consumption 1* (tcs 1) in Figure 11 where the imposition of the MW is thought to leave the number of businesses along with consumption from the unemployed and prices (i.e. the two remaining variables that can influence total consumption) unaffected.

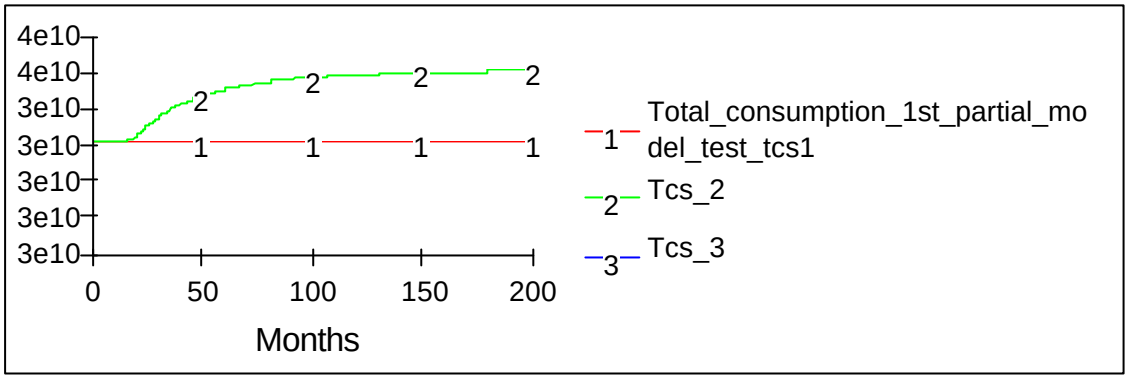

Figure 11 Comparison plot of total consumption for partial model tests 1,2 and 3

If on the other hand we do allow firms to close down as normally expected and hypothesised, still keeping prices and consumption from the unemployed out of the picture, total consumption as we can see from *tcs/2* in Figure 11 ends up at higher levels than originally. The influence diagram presented in Figure 12 sheds some light into what causes this increase in total consumption.

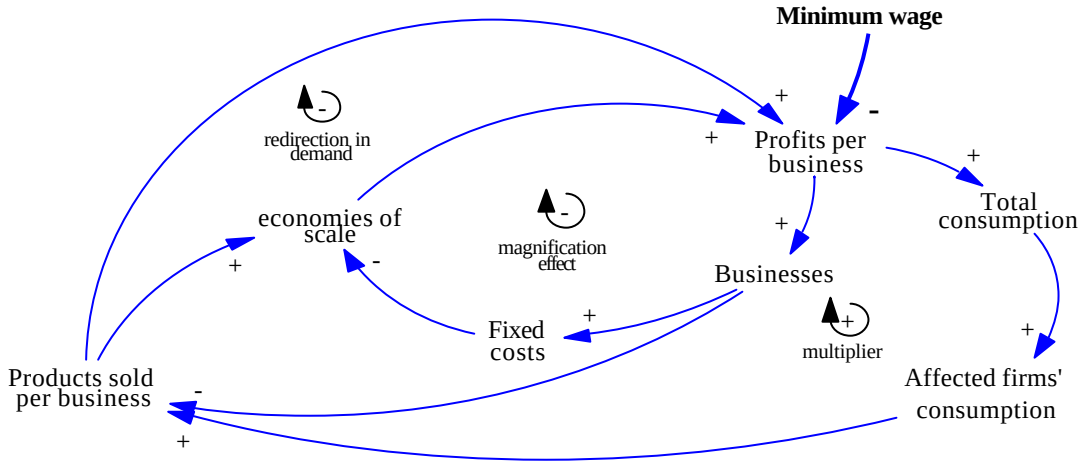

Figure 12 Influence diagram identifying the responsible structure for the behaviour produced in section 2.3.2

After profits per business reduce and some firms close down, all consumption is redirected to existing firms boosting *products* and *profits per business*. Since supply is now increased utilizing less fixed resources however, *economies of scale* are realized and *profits per business* increase even more thereby rising *total consumption*. In other words, the funds that were getting directed to fixed cost payments lowering profits per business are now going into the pockets of (the remaining) entrepreneurs who are assumed to be able to meet the excess demand from existing resources and as a result (since they don't have to spend any more money in terms of fixed costs than they used to) they realize a further increase in profits increasing consumption.

Indeed, if we make the extreme assumption that fixed costs are zero for all affected businesses, total consumption is shown to remain unaffected despite the closure of businesses matching tcs1 exactly (see *tcs3*, Fig 11).

With an increase in total consumption then, the positive multiplier feedback loop is set in motion driving consumption ever higher, until new businesses start entering into the economy activating the balancing magnification effect feedback loop (Fig 12). The number of the affected businesses plotted in Figure 13 (*tbus/2*) which is derived from the second partial model (i.e. assuming positive fixed costs and business closures) demonstrates however that the aforementioned balancing loop is not strong enough to associate a particular number of businesses to a particular consumption level. Thus, even though the number of affected firms almost fully rebounds to its initial levels, the corresponding total consumption (*tcs2* Fig. 11) settles at higher levels than originally due to the previous (permanent) multiplier effects. In the meantime, the boosted demand drives total employment noticeably higher than it originally was (*temp/2* Fig.13).

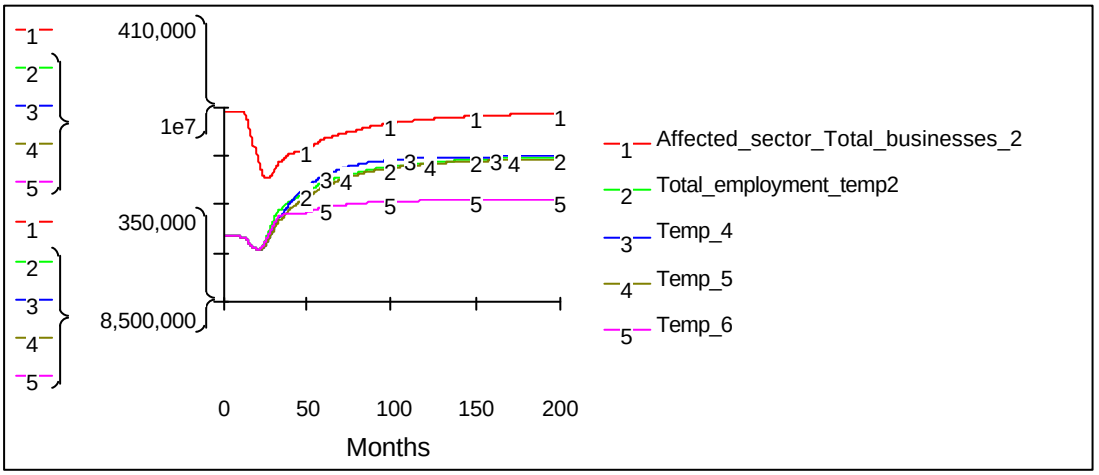

Figure 13 Comparison plot of total employment levels as produced in partial model tests 2,4,5 and 6, and the total number of business in the affected sector as derived from partial model test 2.

The reasons for the considerably higher levels of total employment reached in this run (*temp2* Fig 13) as compared to the ones found in Figure 10 have of course to do with the fact that in the second partial model test (as in all other partial model tests) both selling prices and consumption from the unemployed[14] have been assumed away leaving the multiplier loop to exert its maximum influence in the economy. The

[14] When assuming a constant consumption of the unemployed the mass balance check for the flow of money (see section 2.4) diverts, as expected, from zero.

constraining effect these two variables have on the multiplier loop is not hard to comprehend. Higher prices, as shown in both Figures 3 and 4, act to divert demand away from the affected into the unaffected sector and into imports. To the extent that it is the unaffected sector's demand that increases no major harm is done in the economy since the multiplication effects simply work around the unaffected sector more intensively than before and total employment (temp) levels ultimately reach their top levels (see Fig. 13, *temp/4* as compared to *temp/2*). To the extent that demand gets redirected into imports however, the effect on consumption can be dire as can be imagined since it will be foreign businessmen that will be realizing greater profits in the expense of domestic profitability and consumption. Nevertheless, given the chosen parameters and hypotheses for this run, the demand that gets redirected to imported products because of the MW is miniscule since prices in the affected sector do not rise high enough. Total employment levels therefore fall only slightly below their maximum levels (see Fig 13 *temp/5*) and very little –if any – damage is done to the economy overall.

The greatest actual constrain to the multiplier loop previously described therefore is identified in the face of one of the most widely known automatic stabilizers, the consumption from the unemployed which naturally results from the unemployment benefits that are paid out to them by government. As total employment increases, less money are injected into the economy in terms of unemployment benefits and total consumption naturally falls. As a result, total employment drops considerably below its maximum values (see Fig 12 *temp/6*), matching exactly the levels produced in Figure 10.

2.3.3 Third run: Increased spending and margin restoration pricing policy
In this run we explore some of the consequences that could be expected if the affected firms decided to pass on the increased costs in terms of higher prices, thereby attempting to restore their initial profit margins. Figure 14 shows the behaviour of *total employment* and *total profits* that would result along with the *average selling price* levels that would be charged in the economy.

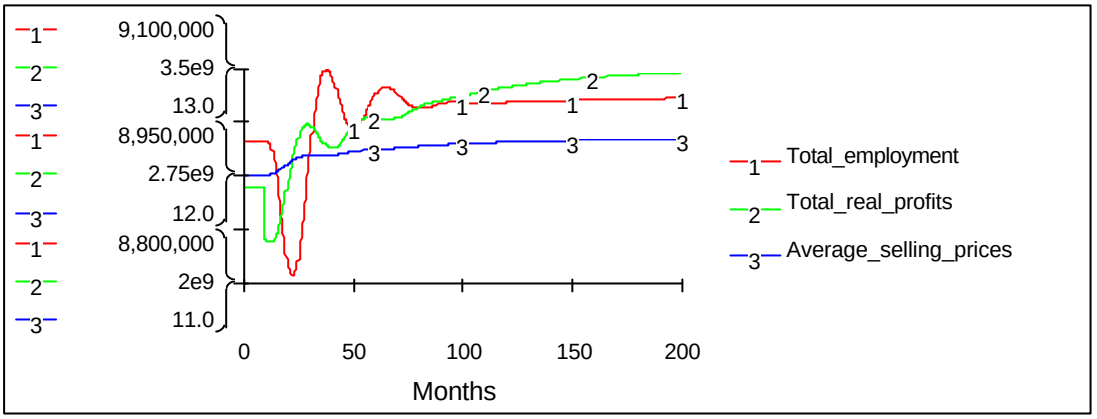

Figure 14 Third main run: Increased spending and margin restoration pricing policy. Plot of total employment, total real profits, and average selling prices

As predicted from the analysis in section 2.3.2, the affected firms' decision to pass on the increase in selling prices clearly compromises the ultimate employment and profit levels that are eventually reached. The reason for this kind of behaviour is none other than the previously identified increase in *imports* (Fig. 15).

A further point that emerges from this run and warrants further attention is the possibility of an inversely related relationship between the employment levels within the affected and the unaffected sectors because of the affected sector's price hikes. Since the initial hypothesis (see Fig 3 &4) was that an increase in the selling prices within the affected sector would redirected at least part of the affected demand into the unaffected sector, the employment levels in that (the unaffected) sector should be expected to increase to the detriment of the ones found in the affected sector. Indeed, as demonstrated by the behaviour of the three remaining variables plotted in Figure 15, this line of events does occur for the reasons just explained.

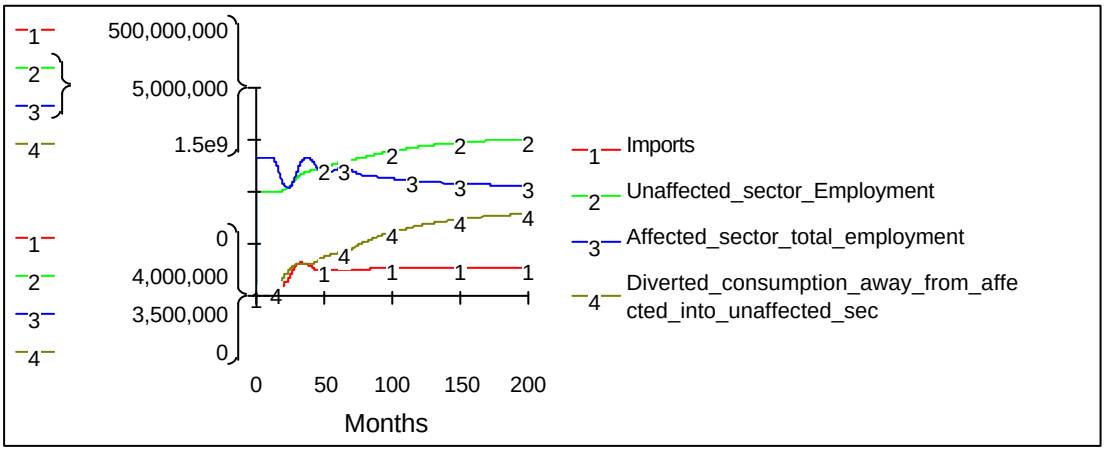

Figure 15 Third main run: Increased spending and margin restoration pricing policy. Plot of imports, affected and unaffected sectors' employment levels, and of the consumption that gets diverted away from the affected into the unaffected sector.

The full repercussions of this important point will be made clear in the following section.

2.3.4 Fourth run: Increased spending and matching permanent productivity gains.

A commonly held view regarding the effects of a biting MW when matching increases in productivity levels are hypothesized, is that any adverse effects usually experienced will be minimized due to the largely unchanged cost structure of businesses. In this run we explore the consequences of an upsurge in productivity within the affected sector of equivalent magnitude as the hike in the MW that could possibly result as a result of the MW introduction, and we identify the reasons for the produced behaviour.

Figure 16 depicts the *total real profits* and *employment* levels that are produced within the affected sector.

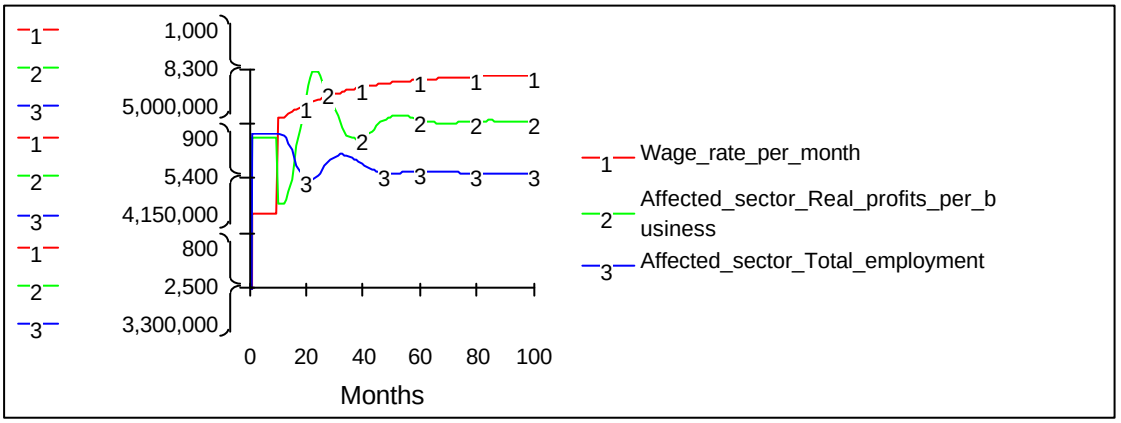

Figure 16 Fourth main run: Increased spending and permanent productivity gains. Plot of wage rate per months, and of the affected sectors' real profits per business and employment levels.

Contrary to what may have been expected, it can be seen that once again the MW will initially reduce real profits per business immediately after its imposition, even though businesses will ultimately benefit from the productivity increases and they will manage to permanently increase their profits[15]. As regards employment on the other hand, it clearly ends up in lower levels than it was originally.

The cause for the reduction in employment has much to do with the initial reduction in firms' profits. Given that total consumption does not change initially with the MW, a permanent increase in normal productivity levels

[15] The fact that boosts in productivity are considered to be realized gradually and not instantaneously makes very little difference to the overall dynamics produced. The equations for an instantaneous productivity increase have been included in the model that would allow the reader to carry the experiment themselves.

cannot benefit firms' profits since the extra output that can be now produced cannot be sold to bring in more money. With permanently increased costs to be paid out and a constant demand then, firms start losing money. In the face of this situation, the firms that do manage to survive the initial drop in profits reduce their employment levels thereby adjusting their supply to the demand levels, cutting wages, and increasing profits. Since profits are then seen to increase, new firms are drawn into the economy and given that a permanent increase in real profits per business has been achieved due to permanently higher productivity, the number of businesses within the affected sector rises while the number of employees per business drops. Figure 17 confirms this hypothesis.

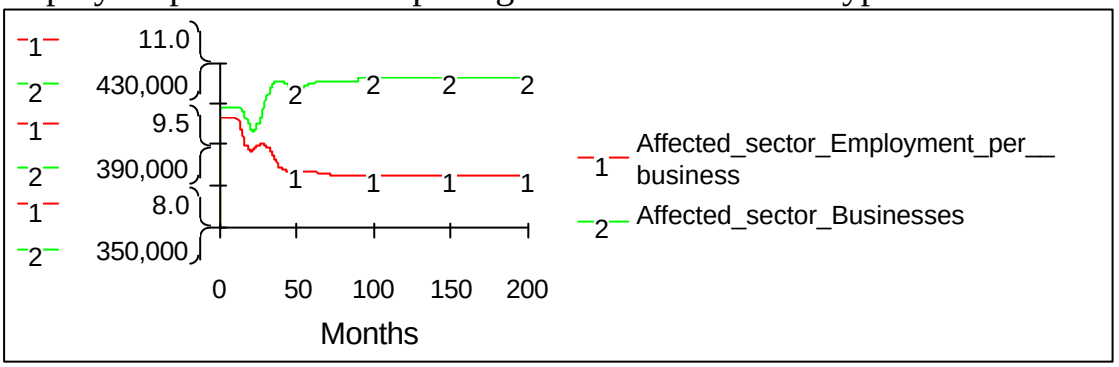

Figure 17 Fourth main run: Increased spending and permanent productivity gains. Plot of the number of businesses and the employment levels per business within the affected sector

The results depicted in Figures 15 and 17 however, cast serious doubt to the implicit assumption taken by many that the effects of a MW can be empirically assessed in a proper manner by merely looking at the employment levels of particular expected-to-be-affected firms before and after a MW imposition. In particular, this appears to be the very assumption that Card and Krueger made when they attempted to empirically assess the effects of a MW hike in the state of New Jersey back in 1992. Card and Krueger (1994 and 1995) surveyed 410 fast-food restaurants before and after a MW increase at stores in New Jersey (where the MW was imposed) and eastern Pennsylvania (where the MW was unaltered) and produced one of the most widely known and referenced MW paper in the economics literature that managed to alter the conceptions of many economists as regards the potential MW effects in an economy. As suggested in this model however, not only would this kind of treatment fail to take into account any possible trade offs between the affected and unaffected sectors, but it would also ignore any alterations in the numbers of businesses within an economy. Such simplifications appear therefore to be quite risky.

2.3.5 Fifth run: Challenging the implicit fixed cost assumption

Up until now the implicit assumption that fixed costs simply constitute a flow that merely reduces entrepreneurs' income was made. Indeed, the beneficial results in total employment and profits levels that were evidenced in section 2.3.2 had been attributed initially to the reduction of this outflow which then acted to increase total consumption setting the multiplier loop in motion. This assumption is now challenged by both extending the model boundary to include an additional consumer group, the rentiers, and by making the extreme additional assumption that all fixed costs are simply rent costs. Any reduction in fixed costs therefore now acts to restrict rentiers' income and consumption leaving total consumption levels unaffected from the number of business in the simulated economy.
Figure 18 shows that even in such conditions, the MW does not ultimately reduce employment levels.

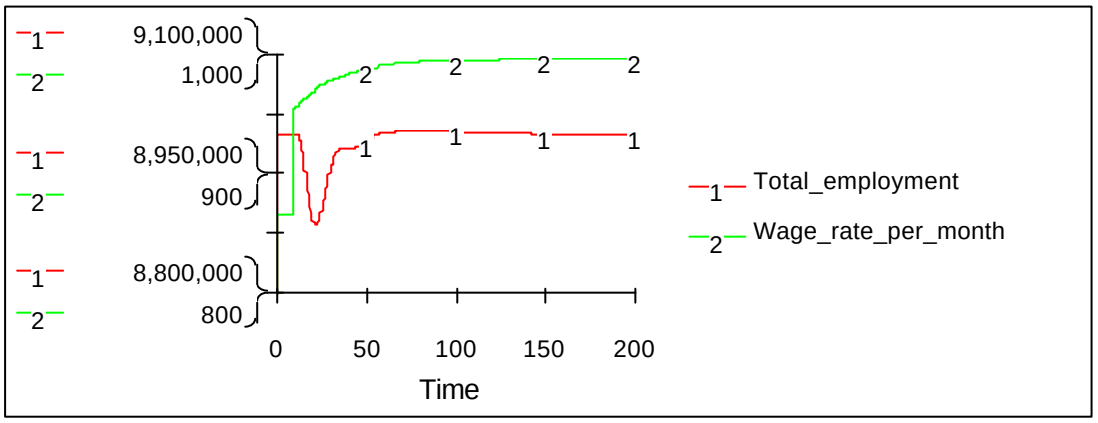

Figure 18 Fifth main run: Plot of total employment, unaffected and affected sectors' employment and the affected sector's average silling price

2.3.6 Sixth-ninth runs: Increased spending, constant productivity, cyclical demand.

In the final runs considered in this paper, an effort is made to identify the effects a MW would have when introduced in different phases of an economy's business cycle. Assuming increased spending and no permanent productivity increases (i.e. adopting the assumptions of section 2.3.2) an oscillatory exogenous consumption is introduced with a periodicity of 60 months to capture the typical 5-year duration of a business cycle, and the MW is imposed when the economy is recovering, booming, going in recession, or is in depression. For the fourth run (run 4) a MW is not included at all to provide a basis for the comparison of the results of runs 5-8.

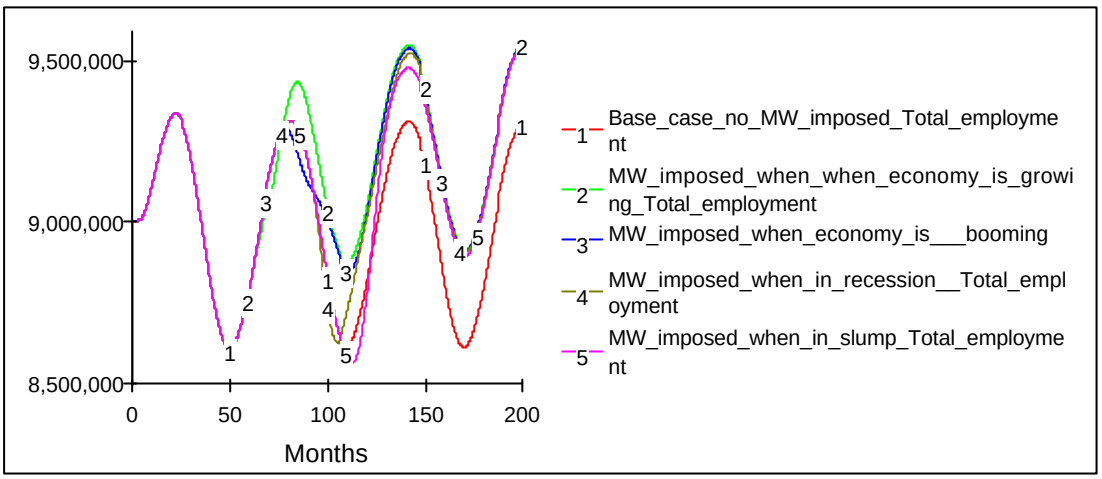

Figure 17 Runs 4-8. Comparison plot of employment

Two things emerge quite eminently from Figure 17. The most surprising of the two perhaps, is the fact that the time of the introduction of the MW in the economy makes absolutely no difference for the longer term well-being of the economy. Under the chosen assumptions then, the MW will eventually act to boost employment levels whenever it is introduced. It must be added of course, that this result is in complete harmony with the previous analysis in section 2.3.2, where under the same assumptions as regards spending and productivity the same results, namely a permanent increase in employment levels, were produced.

Secondly, it is shown that the best time to introduce a biting MW in terms of experiencing the smaller transient effects in total employment levels is either when an economy goes through a recovery stage or when she is booming. It should be intuitively evident that with the introduction of the MW at times of growing demand the initial reduction in firms' profits due to higher costs will be counterbalanced by the stronger sales and consequently profits. As a result fewer firms will close down and the pressure on employment will be limited. When the economy proceeds into the recessionary phase then, the longer term beneficial effects of the MW will make their appearance and the reduction in total employment levels will again be somewhat contained.

It is on similar grounds that the analysis in favour of a MW imposition when the economy is booming is made, although, as shown in Figure 17, the transient dynamics are not exactly the same as with the previously described situation. By imposing the MW at times when demand is about to drop, the fall in employment is somewhat exacerbated, yet because of the quite quick emergence of the beneficial effects of the MW, recession is cut short and the economy gets back on track faster than it would have done otherwise. Conversely, a MW introduced at times when demand is

low or getting lower, will further exacerbate the low employment situation before the beneficial effects of the MW kick in.

Even though this last finding appeals very much to common sense, there have been occasions where it has been disputed by some economists in the past, as George Stigler had done for example some time ago - Stigler(1946 p.362)- arguing that a MW should be imposed when an economy is during a recessionary stage.

2.4 Model testing

A number of different tests were carried in order to build confidence in the model and its findings. Firstly, an attempt was made for the causal structure (described in section 2.1) to be as realistic as possible and disaggregated enough to enable one to draw a number of safe conclusions as regards the potential economic effects of a biting MW. To the knowledge of the authors therefore, the model structure does not include any assumptions that would be contradicted by the structure of a real economy, although a number of simplifications have naturally been made.

Secondly, the fact that the output that gets produced from a number of different partial model tests and reruns can be directly associated to the identified causal structure giving no rise to any suspicious conflicting dynamics goes some way into establishing that no fundamental mistakes should exist in the equations of the model.

Next, some extreme conditions tests were carried, with both the affected and the unaffected sectors assuming values of zero and one in turn[16], while all firms were also considered to shut down in the event of even small reductions in profits. As regards increased prices, the extreme situation where all demand was diverted to imports was tested while, as already described, fixed cost per business have also been assumed to equal zero. The particular modifications required in the model's equations for these alternative runs are all presented at the very bottom of the model's listing.

Fourthly, in an attempt to test the robustness of the firm's conclusions in the face of different time constants, a great number of different combinations was tried. Although it would have been impossible to

[16] The continuous use of the 'ratio' function throughout the model whose purpose is not to allow the denominator of a particular ratio to equal zero was indeed required in order to handle the zeroing out of the sectors if extreme parameter values for a and b were chosen.

provide the output for even a small part of them, in Figure 20 the degree of this model's robustness is presented through the plot of the total employment levels derived from the assumptions made in section 2.3.2 given a doubling and a halving in all time constants.

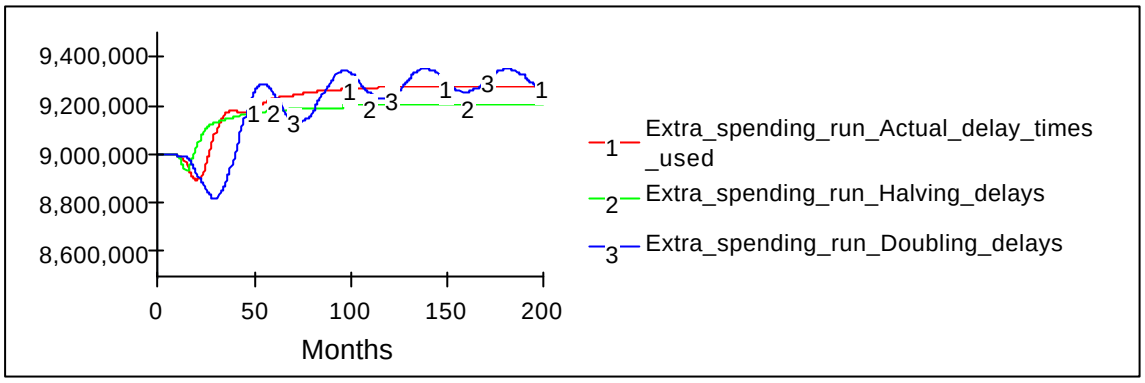

Figure 20 Sensitivity test. Doubling and halving delay times

Consistent with all other observations made from other such time varying combinations, Figure 2.3.2 shows that whether the chosen time constants approximate reality or not is of little significance in this particular case.

Lastly, the model's behaviour has been tested with a reduced time step (i.e. dt=0.125 instead of dt=0.25) and the length of the simulation was doubled to make sure that no surprising dynamics were produced, while mass balance checks have been calculated for the flow of money due to its highly cyclical nature. A dimensional consistency check and an inspection of whether any premature dynamics are produced were also performed.

3 CONCLUSIONS

The traditional neoclassical approaches to the effects of the MW fail to take into account the vast complexities associated with this scheme, and their results, having unfortunately shaped current economic and political thinking, appear to do no justice to the richness of outcomes that may be ultimately produced because of such a scheme. When considering the potential likely effects of a MW therefore, attention is almost exclusively centered on issues that have to do with the immediate changes in businesses' wage bills, profits, product prices and employment levels. The possibility of any dynamics occurring after the MW imposition is generally not contemplated with, with the only exception probably being that if the MW is set at too high a level differential pressures could emerge driving wages higher still.

In this paper a model is presented that tries to do some justice to the complexities involved with the MW. An approximately 210 variable model is consequently described that allows for a series of different assumptions to be tried and tested and its result prove to challenge current economic wisdom in many ways. It is demonstrated that variables that are not even contemplated within the traditional neoclassical framework such as consumption spending and fixed costs should be at the forefront of the economic analysis since they, alongside imports, are the ultimate determinants of the economic effects of the MW. The possibility and the reasons behind a longer term permanent increase in both profit and employment levels is also highlighted and trade offs in both of these variables between firms whose wage structure remains unaffected from the MW and affected firms, are also shown to be more likely than not. Finally it is shown that the MW can result in an increase in the number of businesses and a parallel reduction in the employment levels per business, or a reduction in the number of firms and an increase in their associated employment levels.

REFERENCES

Card, D. and A. Krueger, 1994. Minimum wages and employment: a case study of the fast food industry in New Jersey and Pennsylvania. *American Economic Review*, vol. 84(4), pp. 772–793.

Card, D. and A. Krueger, 1995. *Myth and Measurement – the New Economics of the Minimum Wage.* (Princeton New Jersey: Princeton University Press).

Coyle R.G., 1996. *System Dynamics Modelling: A practical approach.* (Chapman and Hall).

Coyle R.G., 1999. Simulation by repeated optimization. *Journal of the Operational Research Society*, vol. 50(4) pp.429-438

Dangerfield B. and C. Roberts ,1996. An overview of strategy and tactics in system dynamics optimization. *Journal of the Operational Research Society*, vol. 47, pp.405-423

Dickens, R., S. Machin and A. Manning, 1994. Minimum wages and employment: a theoretical framework with an application to the UK Wages Councils. *International Journal of Manpower*, vol. 15(2/3), pp. 26–48.

Edwards, P. and M. Gilman, 1998. *A national minimum wage: stimulus to economic efficiency?* Warwick Papers in Industrial Relations No. 59. (Manchester: USDAW).

Forrester J., 1965. *Industrial Dynamics* (4th printing, MIT press)

Forrester J., 1991. System Dynamics and the Lessons of 35 Years, in *The Systemic Basis of Policy Making in the 1990s*, ed. De Greene, Kenyon B.

Also freely available in:

http://web.mit.edu/sysdyn/people/jay-forrester.html

Kosko, B.,1994. *Fuzzy Thinking. The New Science of Fuzzy Logic*. (Flamingo)

Machin, S. and A. Manning, 1994. Minimum wages, wage dispersion and employment: evidence from UK Wages Councils. *Industrial and Labor Relations Review*, vol. 47(2), pp. 319–329.

Mayer T., 1993. *Truth versus Precision in Economics.* (series of: Advances in economic methodology, Edward Elgar Publishing Ltd)

Nolan, P., 1989. Walking on water? Performance and industrial relations under Thatcher. *Industrial Relations Journal*, vol. 20 (2), pp.81-92

Sterman, J., 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. (Irwin McGraw-Hill)

Stigler, G.J., 1946, The economics of minimum wage legislation, *American Economic Review*, vol.36, June, pp.358-365

Back to the Top