Classical Economics on Limits to Growth

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Abstract

Neoclassical economics seems to have rejected the concept of limits to growth by assuming that the market and the technological advances invoked by it will make it possible to tap new resources and create substitution of production factors, while it has outright excluded limitations invoked by the political, psychological and social institutions in its analysis. Classical economics, other the other hand, appears to have been cognizant of a multitude of limitations to growth, including demographic, environmental, and social. This paper reconstructs classical economic growth models using system dynamics method and demonstrates their behavior using computer simulation. A case is made for taking a pluralistic view of the growth process and reincorporating a multitude of institutions driving it into our models to arrive at realistic policy options.

Key words: **economic growth, classical economics, system dynamics, computer simulation, environment, limits to growth.**

Introduction

This paper reconstructs the demographic, environmental, and social limits to growth as posited in the classical economic growth models of Adam Smith, David Ricardo, Thomas Malthus, Karl Marx and Joseph Schumpeter. System dynamics modeling and computer simulation is used to demonstrate the systemic perspective and the richness of these models. The multiplicity of the institutions and the non-quantifiable factors the classical economics models took into account while attempting to explain the dynamics of the growth process, according to Baumol (1959), indeed described magnificent dynamics that were relevant to their respective empirical contexts. The purpose of the paper is to provide a vehicle for understanding classical thought on economic growth and to reiterate the importance of the variety of behavioral and demographic factors and the non-quantifiable soft variables it subsumed. In the complex world of today, it would be impossible to ignore these variables without losing sight of the important dynamics that we experience in reality.

System dynamics modeling allows including such variables in a formal analysis framework. Elsewhere, I have also attempted to understand the development of many of the present day problems including income distribution (Saeed 1987, 1988), political instability (Saeed 1990), global terrorism (Pavlov, Radzicki, Saeed 2005), environment (Saeed 2004), technological development (Prankprakma and Saeed (1997) and innovation in organizations (Saeed 1998) by taking including soft variables in my models and the reader is referred to these studies for the modeling details of such variables.

The concept of limits in economic thought

Neoclassical economics mostly excluded environmental, demographic and social limitations from its formal analyses until early 1970s, although it extensively addressed the periodic limitations to growth arising out of the stagnation caused by imbalances in the market. As an exception, Hotelling (1931) dealt with exhaustible resources with concerns that the market may not be able to return optimal rates of exhaustion, but without pessimism about the technology to bring to fore new sources as old ones are exhausted. These early concerns have been followed by a blissful confidence in the ability of the technological developments and prices to provide access to unlimited supplies of resources (Devarajan and Fisher 1981, Smith and Krutilla 1984).

Solow’s 1974 Richard T Ely lecture made a strong argument for integrating depletion of resources into the models of economic growth (Solow 1974), but the momentum of orthodox economics effort has nonetheless not deviated much from its earlier focus on optimal rates of depletion and pricing of resources (Nordhaus 1964, 1979) without concerns for environmental capacity, which are mostly expressed in passing. There have been some concerns also expressed about intergenerational equity, but its treatments remain tied to arbitrary rates of discount (Hartwick 1977, Solow 1986). Environmental analysis seems to have appeared as an add-on in response to the environmental movement spearheaded by the famous *Limits to Growth* study (Forrester 1971, meadows, et. al. 1972, 1974, 1992). In this add on, the neoclassical economic theory has continued to assume mineral resources to be unlimited and to expect prices and technological developments to continue to unearth richer mines so existing mines may be abandoned (Saeed 1985). The reality of political power, the creation and resolution of social conflict and the psychological and behavioral factors also remain excluded from the classical analysis, although they contribute significantly to the performance of the economies (Street 1983).

Classical economics, on the other hand seems to have addressed a rich variety of limiting factors covering social, political, demographic and environmental domains often dealing with soft variables that are difficult to quantify but that have significant impact on behavior of the economy. In particular, the growth models proposed by Adam Smith, Karl Marx, David Ricardo, Thomas Malthus and Joseph Schumpeter dealt with such limiting factors using soft variables that cannot be measured and quantified in the neoclassical economics tradition. System dynamics modeling allows us to subsume these variables in the formal models and understand the structure of the classical growth theories with relative ease. The models discussed below are programmed in ithink software.[1] Model equations and machine readable versions are available from the author on request.

Adam Smith and the demographic constraint to growth

Although Adam Smith did not explicitly discuss the constraints to growth, implicit in his model is the demographic constraint since labor is an autonomous production factor assumed to be freely available, while capital is endogenously created through investment of profits (Smith 1977). Also, land which is a proxy for renewable resources, can be freely substituted by capital (Higgins 1968, pp 56-63). Figure 1 illustrates the simple

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relationship between the production factors and the output implicit in Adam Smith's model.

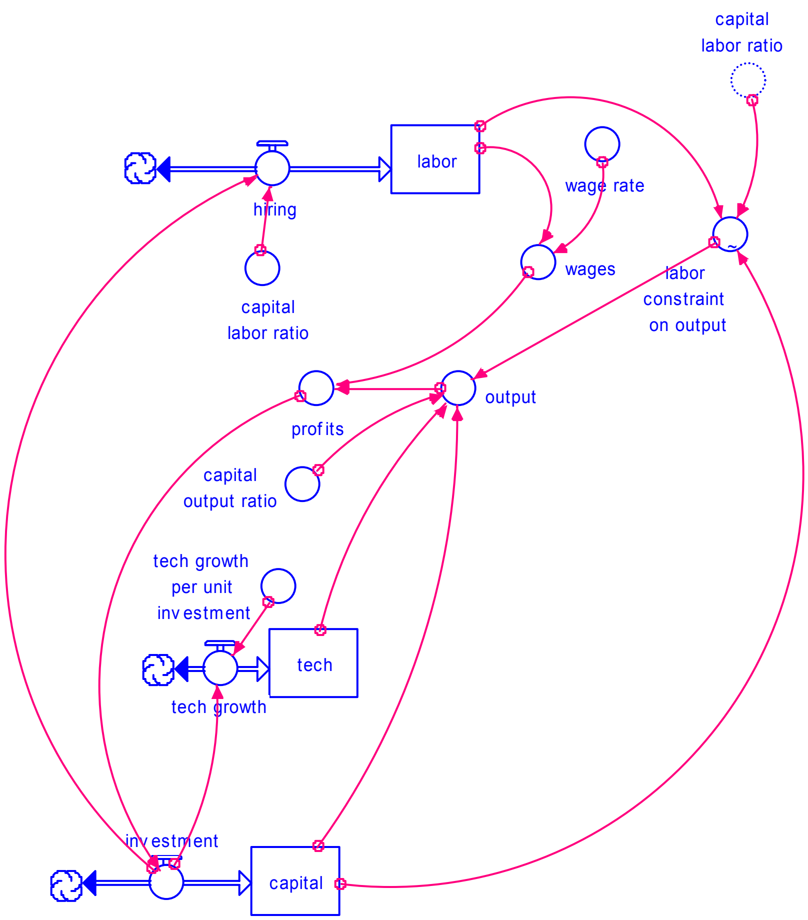

Figure 1: Growth of output and production factors

When land is excluded from the production schedule, the capital input and the labor constraint return a Cobb Douglas type production function, while the influence of technology is exogenous. Growth in any one of the inputs to production can create a growth in the output, however, while Adam Smith gave an endogenous explanation of how capital and technology grew, he did not discuss any limitations on the growth of labor, assuming in default that population growth would continue to provide sufficient quantities of labor so the labor constraint on output does not become active.

Investment, which is driven by profits, drives all: capital formation, technological growth and labor hiring. In the absence of any demographic constraints this would create three powerful positive feedback loops causing explosive growth as long as the wage bill remains less than the output and the system yields positive profits. Add the labor market constraint and wage escalation when labor market becomes tight as shown in Figure 2a, and the profits go to zero pretty quickly while the system equilibrates at full employment as shown in the simulation of Figure 2b.

A sustained growth in this system is possible only when a growth in the total workforce can sustain a pool of unemployed that also keeps wage rate from escalating. Indeed, a sustained growth is obtained when population growth structure is added as in Figure 3a. Simulation of this model is shown in Figure 3b.

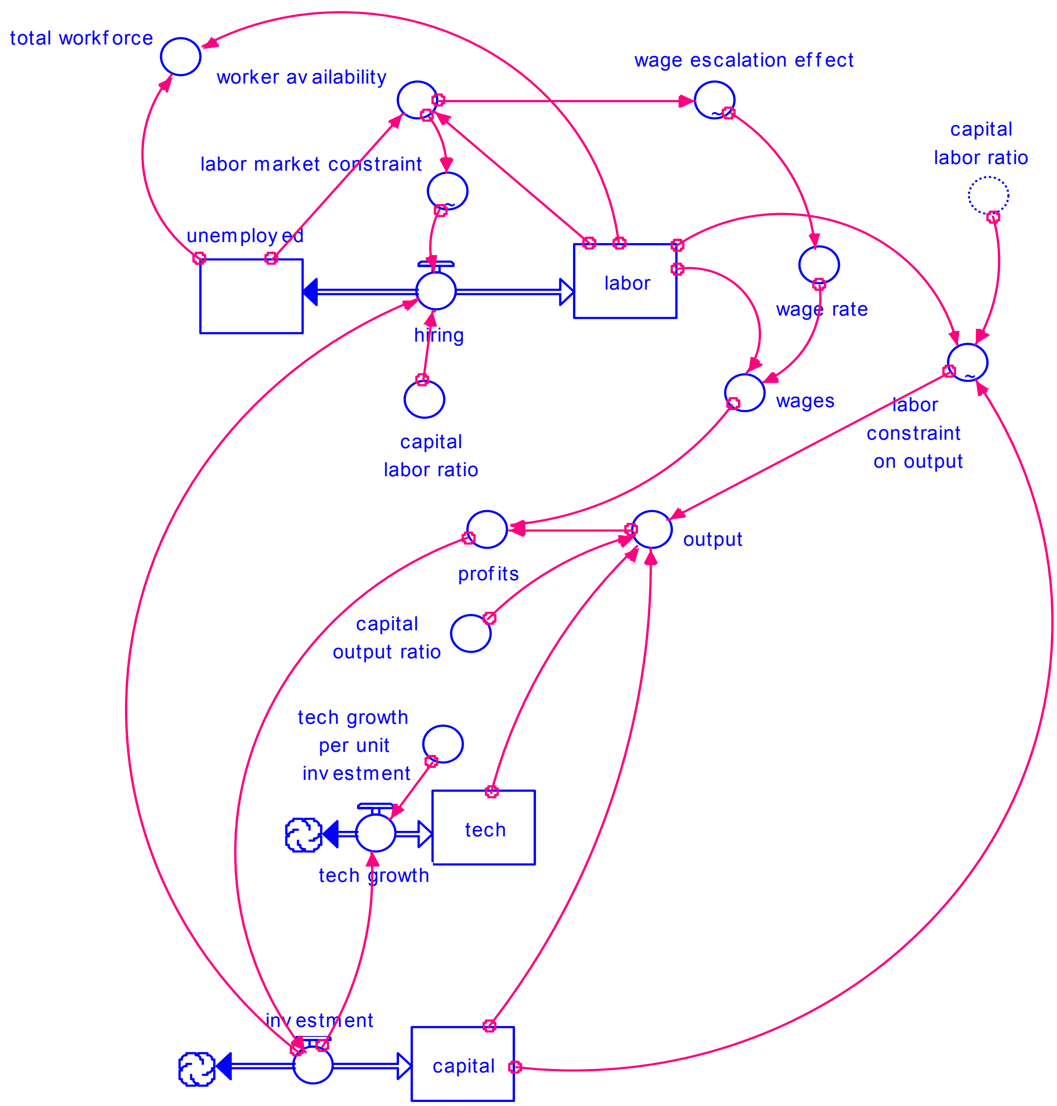

Figure 2a: Demographic constraints added to the model of Figure 1.

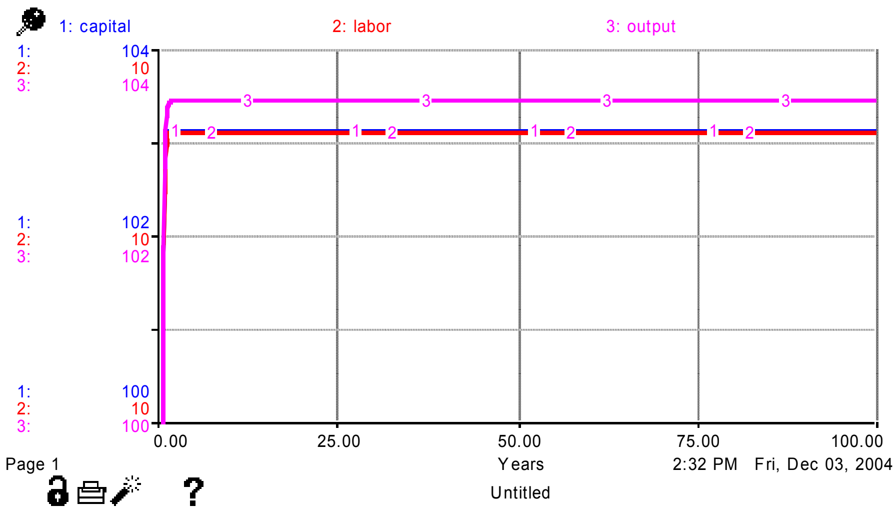

Figure 2 b: Behavior of the model with demographic constraints.

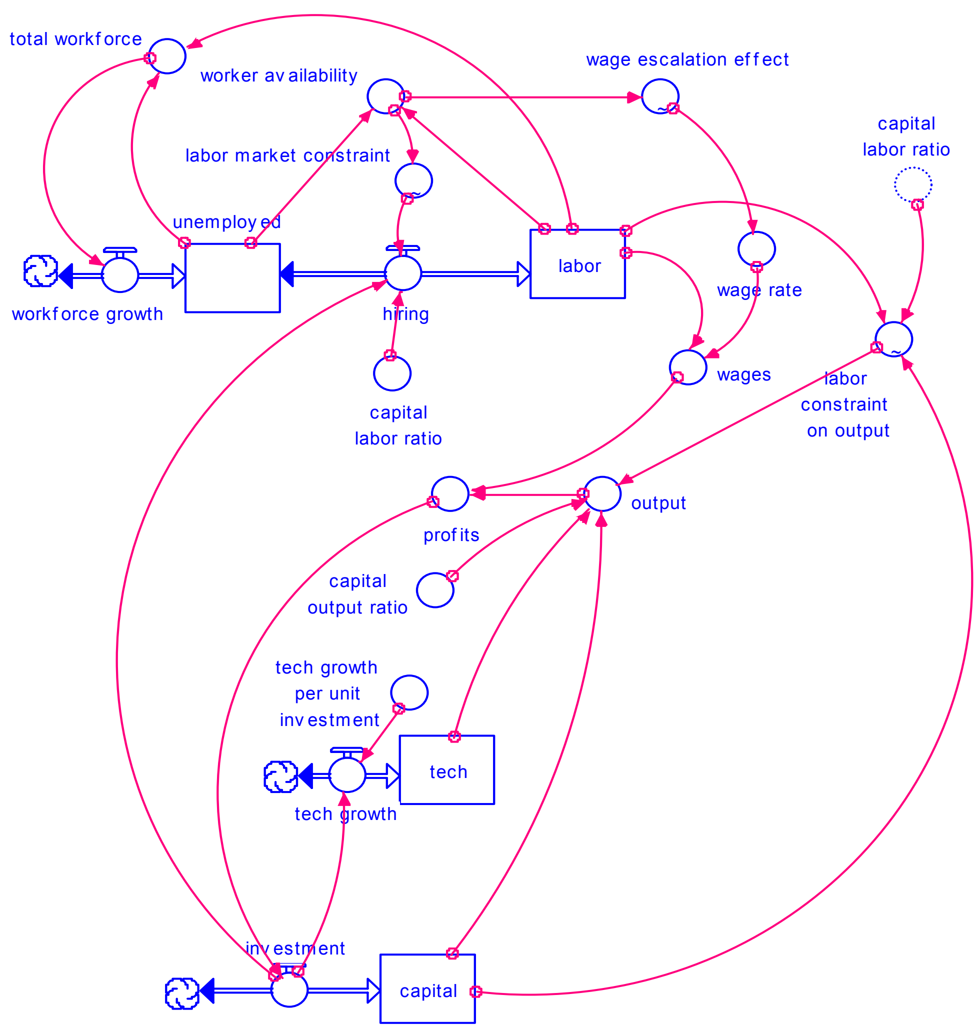

Figure 3a: Population growth added to the model of Figure 2a

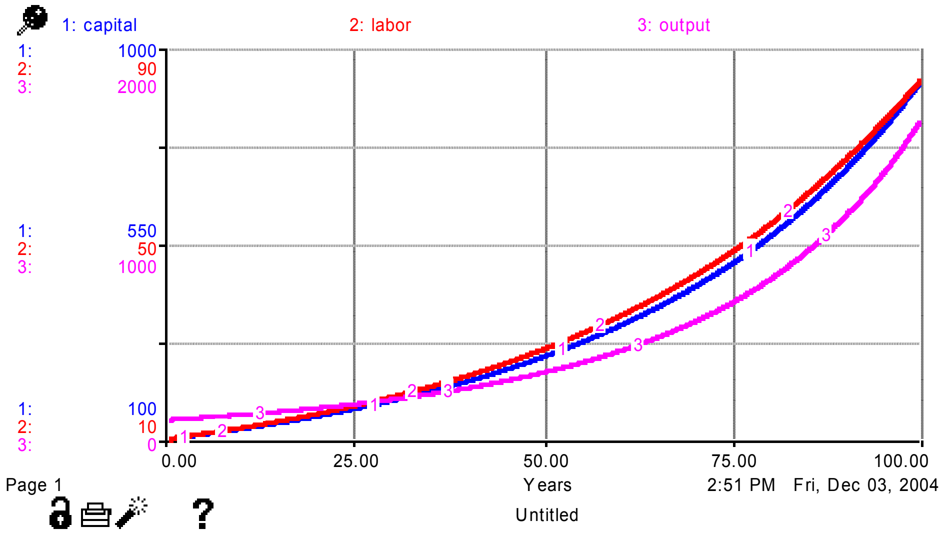

Figure 3b: Economic growth supported by population growth

A land or renewable resource constraint added to this system would slow down the rate of exponential growth, but would not bring it to a halt as long as the labor pool is growing since capital can substitute land and the marginal product of land can increase as other production factors grow. This is shown in the simulation of Figure 4b resulting from the model structure in Figure 4a. Evidently, population growth that creates a growing supply of labor is critical to maintaining economic growth in Adam Smith's model. Hence, the demographic constraint is the unwritten limit to growth since all else is driven by the profits which would decline to zero when a tight labor market caused by a fixed population creates wage escalation. Also note that there is no surplus or deficit of supply and demand in the model and all production is consumed, implicitly meaning that income is widely distributed and both profit and wage components are distributed to the households, hence the demand for goods and services depends on the total income rather than a part of it. This implies that capital ownership is widespread that creates household claims to profit across board. This assumption seems to be the essence of Say's law that eventually became imbedded in the supply side neoclassical growth models although it was repudiated in the writings of Ricardo, Malthus and Marx, who were concerned about the class structure and how it affected income distribution, supply and demand, and economic growth.

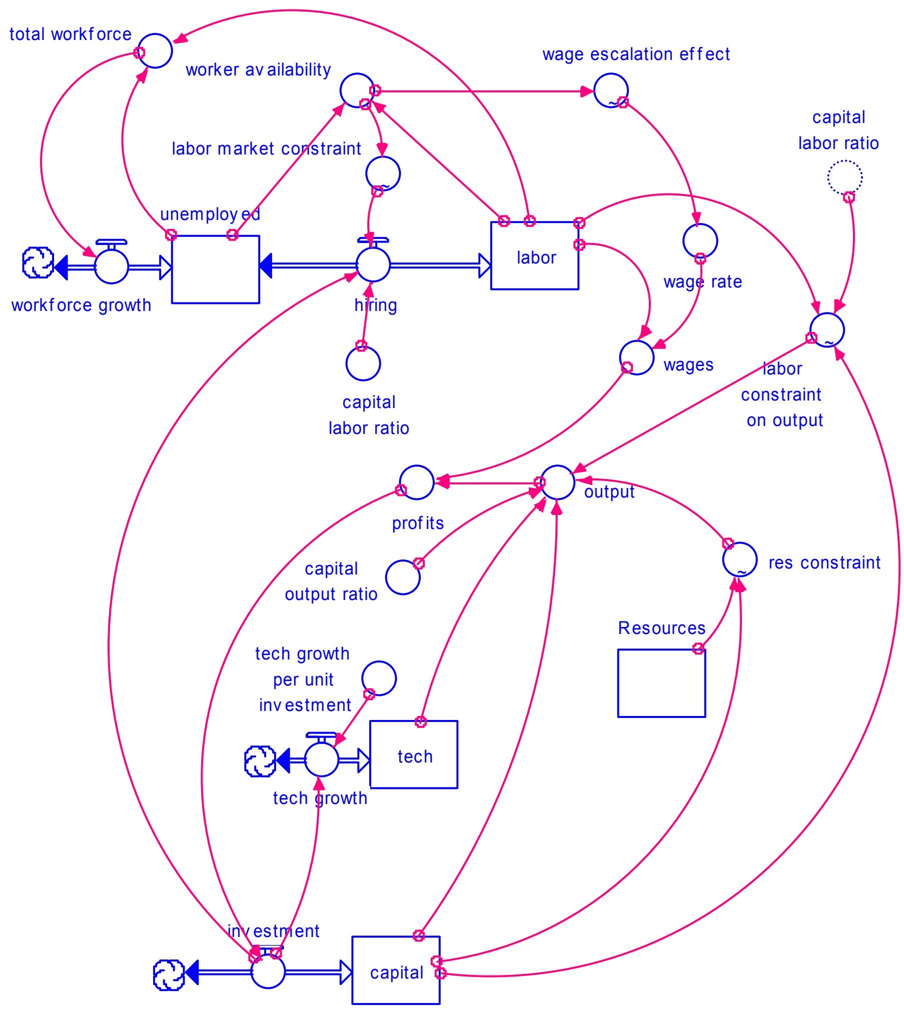

Figure 4a: Renewable resources constraint (Land) added to the model.

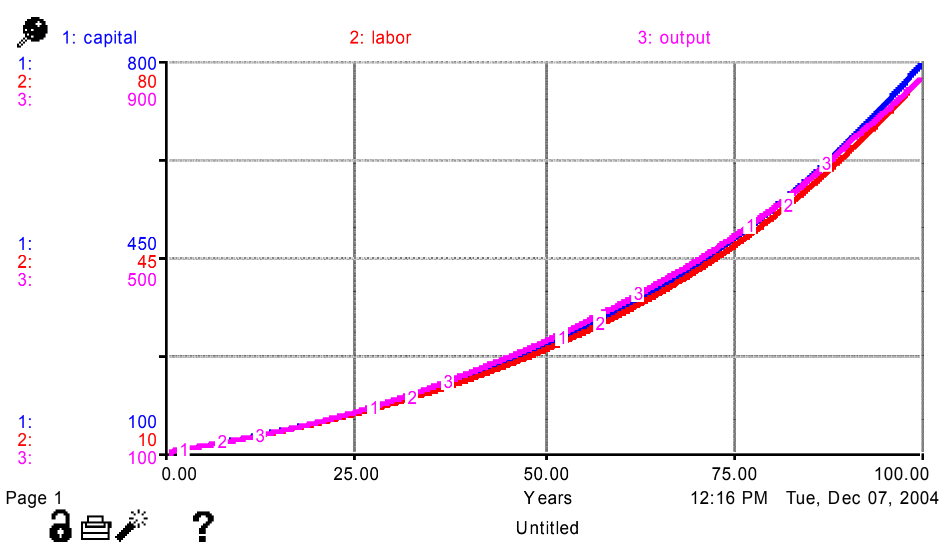

Figure 4b: Behavior with land constraint, when population is growing

Ricardo's iron law of wages and the principle of diminishing marginal rents

David Ricardo was a contemporary of Malthus and a forerunner of Marx. He initiated a debate on the theories of value that still occupies economists today. He also outlined the principles of distribution between the various economic classes, landlords, capitalists and workers which later became important building blocks of the model of growth and decline of capitalism that Marx conceived. Last, but not least, he brought in the constraints to growth by stating his famous iron law of wages and the law of diminishing returns to land cultivation (McCulloch 1881) .

The iron law of wages linked population growth to the wage bill and predicted that population would grow until wage rates equilibrated at a subsistence level. The wage bill divided by subsistence wage, therefore, returned the demographic capacity to supply labor. He also assumed that land was a fixed constraint, meaning the resources it represented did not deplete or were renewable. However, each additional unit of output would require more extensive use of capital and labor. Thus, when the population came to a balance, all marginal land would have been used and all labor employed. At this stage, the marginal returns on cultivating an additional unit of land would fall to zero while the marginal product of labor equaled the subsistence wage. Ricardo extended this principle also to mineral resources, but apparently without expressing a concern for running out:

"The return for capital from the poorest mine paying no rent would regulate the rent of all the other more productive mines. This mine is supposed to yield the usual profits of stock. All that the other mines produce more than this, will necessarily be paid to the owners for rent." (Ricardo 1817)

Ricardo furthermore argued that rate of profit and rents were determined residually in the agricultural sector. He then used the concept of arbitrage to claim that the agricultural profit and wage rates would be equal to their counterparts in the industrial sectors. With this theory, he could show that a rise in wages did not lead to higher prices, but merely lowered profits (New School url on Ricardo).

The model I have presented in Figure 4 is modified further to incorporate the structure underlying the iron law of wages and the diminishing returns on land suggested by Ricardo. Figure 5a shows the model with this modification. Wage bill now determines the demographic capacity to supply labor. As shown in Figure 5b, workforce growth rate is driven by the discrepancy between the demographic capacity and the current workforce.

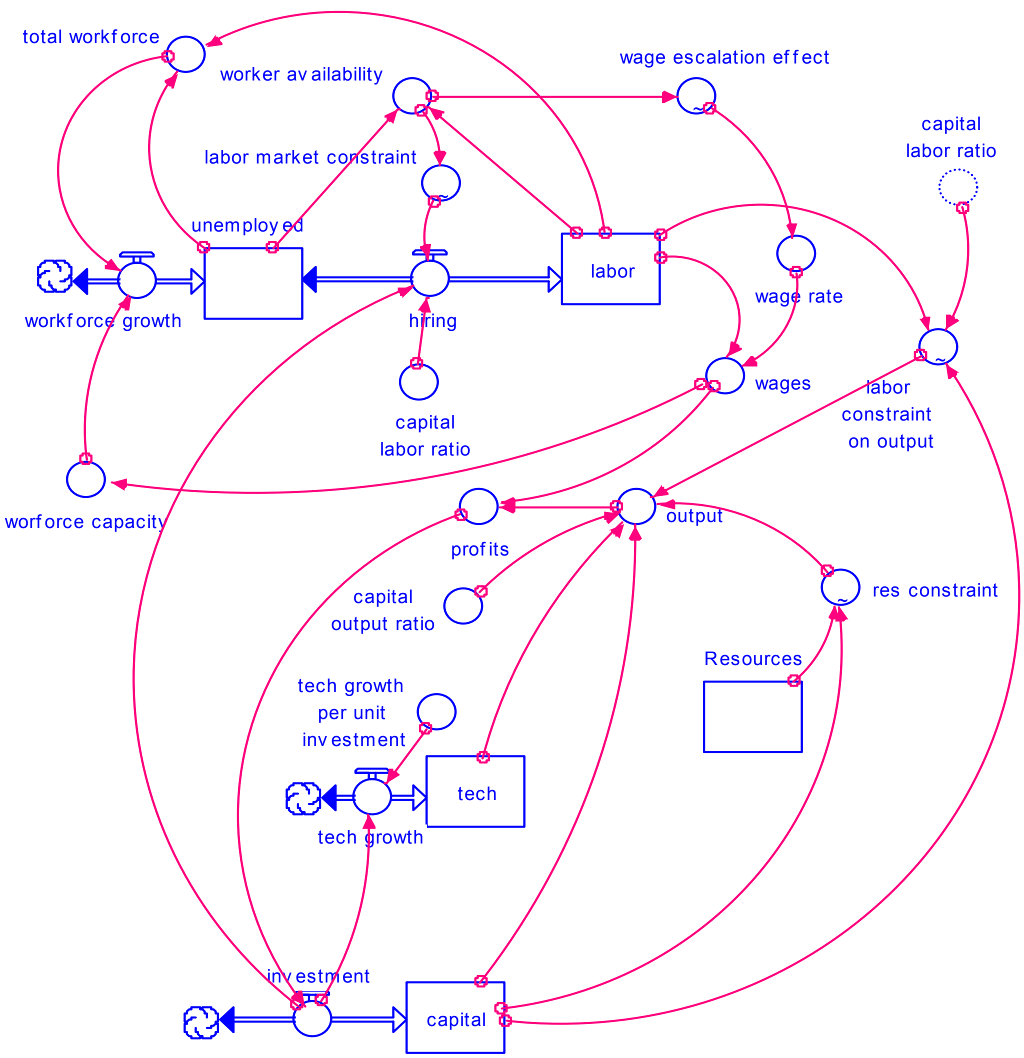

Figure 5a: Ricardo's iron law of wages and the concept of diminishing rents added to the model

The wage rate rises at first as the economy grows faster than the labor supply thus creating tightness in the labor market, but as marginal output declines while workforce continues to grow, a rising unemployment rate forces the wage rate to decline and it comes to a balance at the subsistence level. The profits (which subsume land rents) decline also even though they grow at first.

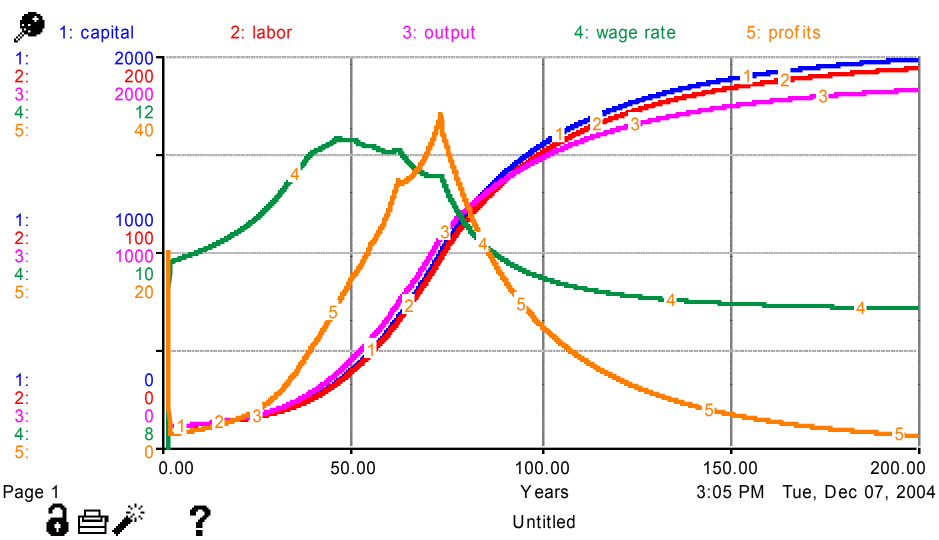

Figure 5b: Simulation of the Ricardian model of economic growth.

In the final equilibrium, the wage rate equilibrates at the subsistence level, while and profits decline to zero. The population has grown to the level determined by the wage bill that provides enough subsistence to the workers so they can produce, but no more.

Thomas Malthus and repudiation of Say's Law

Thomas Malthus, published ideas similar to Ricardo's almost simultaneously as Ricardo wrote. He surmised that population growth by itself is not enough to bring economic advances. He felt that population growth is an *end product* in the economic growth process, rather than a means. He posited that an increase in population cannot take place without a proportionate or nearly proportionate increase of wealth (Malthus 1920).

Another assumption implicit in the simple model I have presented is the so called Say's Law meaning supply creates its own demand which assures that all production is consumed. While Ricardo seems to have implicitly subscribed to Say's Law, Malthus, in fact, repudiated it by differentiating between profits and wages and emphasizing the importance of demand that is linked mainly to the wage income. Marx later presented a more detailed analysis of the consequences of an imbalance between wages and profits. (Higgins 1968, pp67-75)

Malthus was also concerned with what he described as population explosion and the scarcity of resources resulting from it, although it is not clear whether he considered resources in the framework of fixed land, which does not get depleted or nonrenewable resources, which get depleted. Hypothetically, if a resource depletion process is added to the model of Figure 5, an overshoot and decline behavior outlined in Forrester's World Dynamics and the Limits to Growth/ Beyond the Limits studies is obtained (Forrester 1971, Meadows et. al., 1972, 1974, 1992). The structural modification needed for this is shown in Figure 6a and the resulting behavior in Figure 6b.

Forrester has sometimes been accused of replicating the Ricardian/Malthusian model, but he clearly has dealt with nonrenewable resources while the earlier thinkers seemed to be dealing with non-depleting land or renewable resources. Also Forrester disaggregated the limits into an array that further dealt with environmental degradation arising out of economic growth and population growth which could create constraints on growth while material resources were still plentiful. He also introduced the concept of decisions in bounded rationality and the delays in recognition of the information on which the bounded rational decisions of economic actors are based and how these limits could cause an overshoot and decline in population (Radzicki 1988, Morecroft 1985). This way, Forrester provided a far more succinct theory of limits to growth than posited in the classical economic theories.

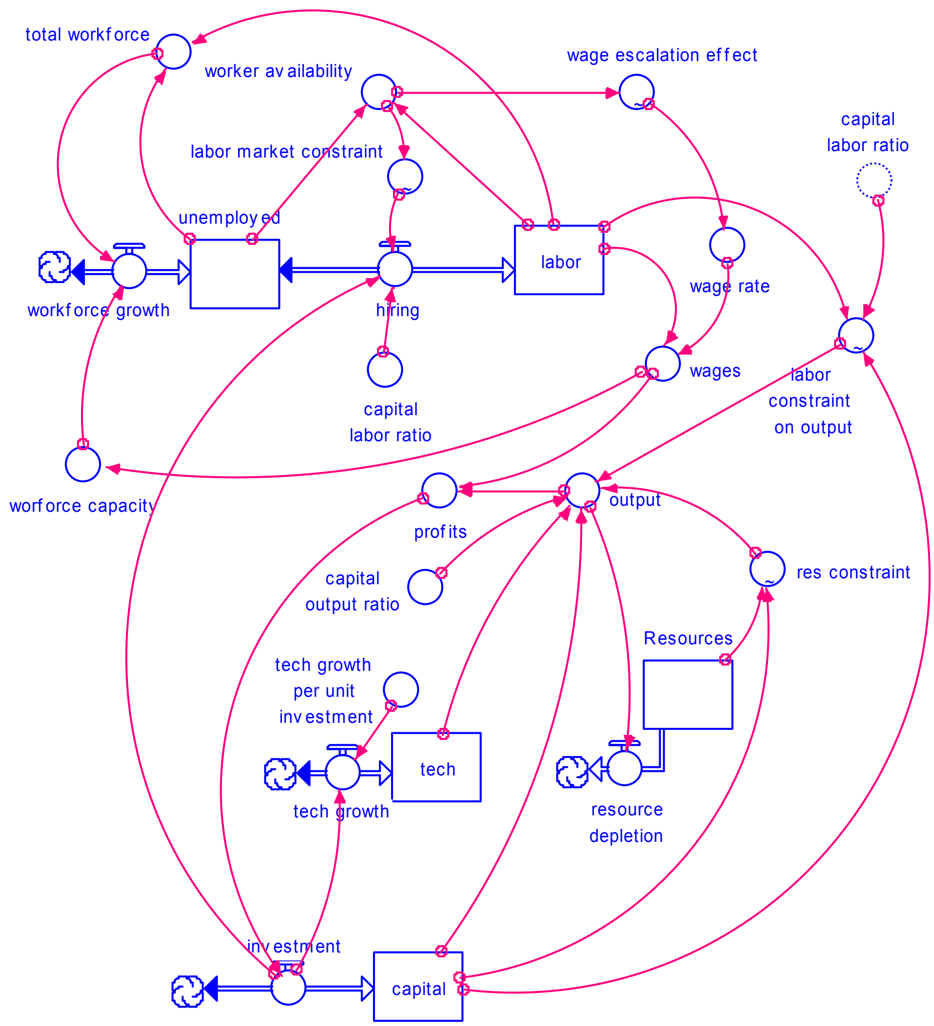

Figure 6a: **Ricardian model with depletable resources**

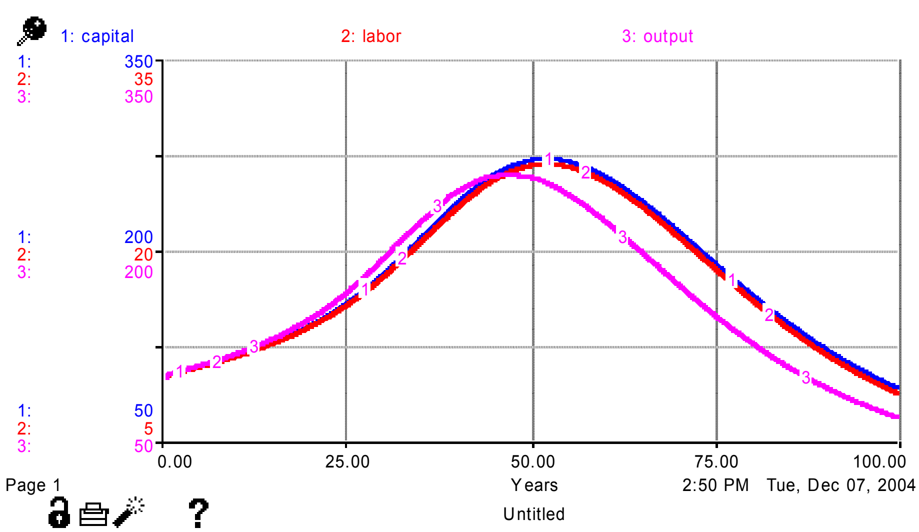

Figure 6b **Overshoot and decline behavior obtained from Ricardo's model with depleting resources**

Marx's model of the downfall of capitalism

Marx added a new twist to the concept of limits to growth by tying them to the social and political factors. He saw these limits arising out of social conflict emerging from income distribution rather than resource limitations. He took an exploitative view of economic growth and posited that it arose out of appropriation of the surplus value by the capitalists. Such exploitation is made possible only when there is a large pool of unemployed labor so workers can bargain for only subsistence wage irrespective of their contribution to production, which is achieved by the capitalists by creating labor-substituting technological advances.

Marx distinguished between the use value and exchange value of a commodity, the later being proxied by the market price. He also postulated a social division of labor, in which different people produced different products, so an exchange could occur. As the ultimate volume of demand for these commodities emerged from the disposable income of the households, a large pool of unemployed would eventually stifle this demand. Marx thus clearly repudiated Say's Law.

Marx also introduced the concept of rate of return on capital that influenced the rate of investment. Marx's logic is sometimes criticized since in his model investment continues even when the rate of return turns down. He assumed that available profit will be invested until the rate of return goes to zero, while profit is the result of the labor performed by the worker beyond that necessary to create the value of his or her wages. Thus profit arises out of the surplus value of labor, which is referred to as the surplus value theory of profit.

This investment structure was indeed consistent with Marx's distinction between the capitalists who receive all profits and do not have to accrue any capital costs to justify an investment decision, and the asset-less proletariat who received only wages. Thus, unlike the neo-classical model, the rate of return in Marx's model was not the only factor determining investment. So, even when the rate of return declined, surplus value accrued as profits needed to be invested. Only when both profits and the rate of return became zero did the investment finally atrophy. Marx did indeed make the prediction that the rate of profit will fall over time, and this was one of the factors which led to the downfall of capitalism. The rate of return declines as the unemployed proletariat is unable to buy the end commodities and the production capacity cannot be utilized, leading to the creation of idle capital (Wolff 2003, Higgins 1968, pp 76-87).

Figure 7a shows the structure of Marx's model that is common to the earlier models of this paper with the difference that technological development is assumed to be labor substituting. Thus technology affects capital labor ratio rather than the output. Also, the rate of return affects the investment decision in addition to the profits. And the capital is divided into two categories, capital in use and idle capital. The hiring depends on the discrepancy between desired labor and labor instead of being directly driven by the investment rate. The desired labor in turn is determined by the capital in use and the capital labor ratio. Figure 7b shows the complete model.

The rate of return on capital is determined by real profit per unit of capital multiplied by price. The price in turn depends on supply and demand. Here is where Say's Law is repudiated. The demand depends on the wage bill while the supply is created by the capital in use and the employed labor. The capital in use is the difference between the capital and the idle capital which depends on capacity utilization. Capacity utilization, in turn, is determined by the demand relative to the supply over the past period. Figure 7c shows the simulated behavior of this growth model.

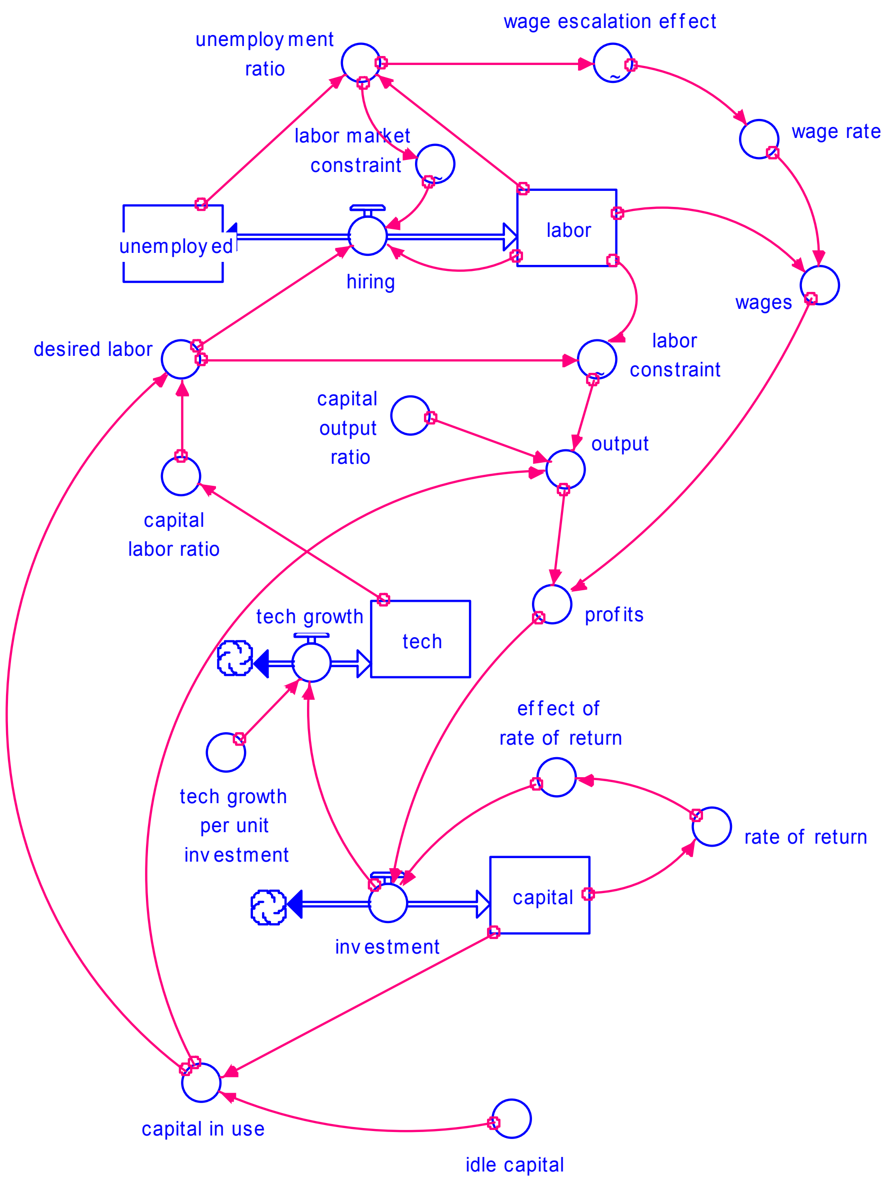

Figure 7a **Labor substituting technological development, rate of return and idle capital added to the growth process as conceived by Marx**

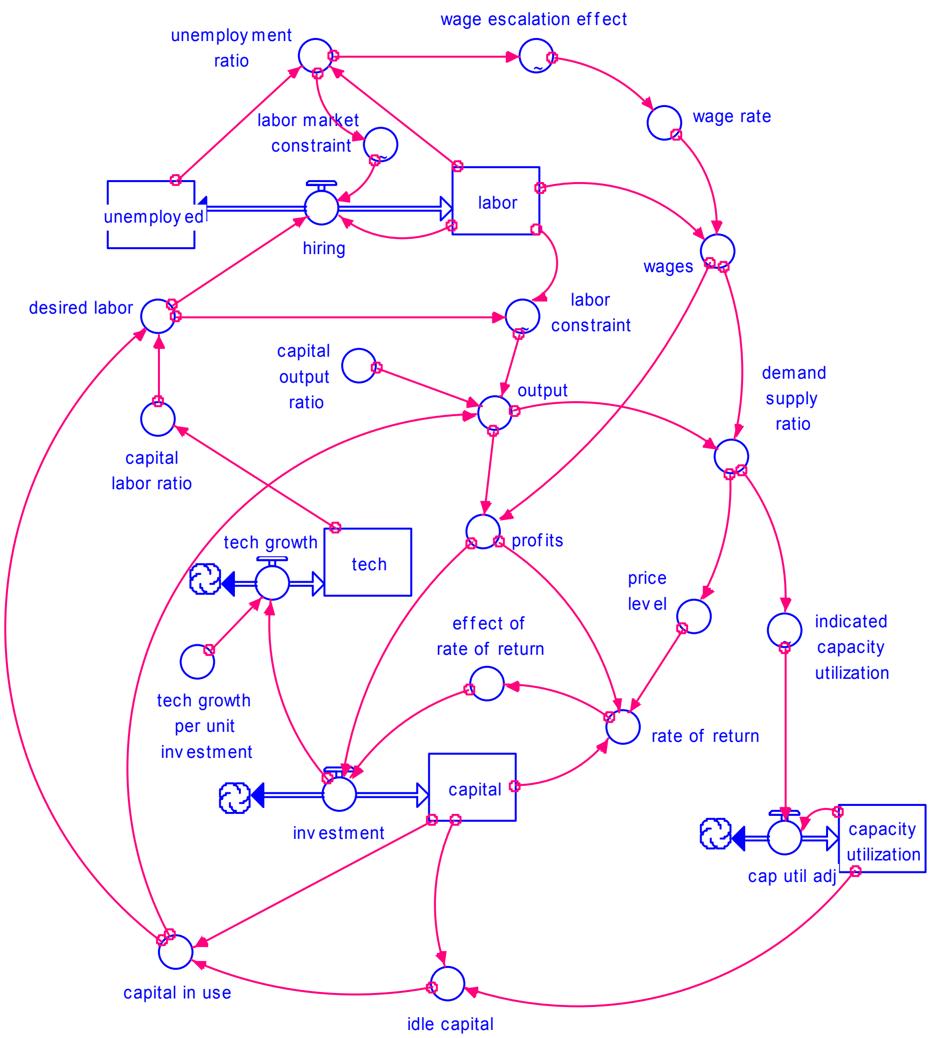

Figure 7b **Marxian model of economic growth**

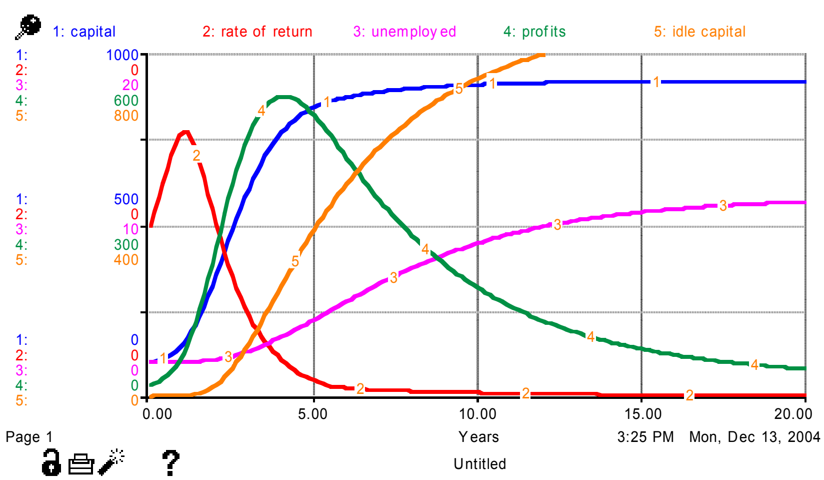

Figure 7c **Decline of rate of return and profits, and the creation of a reserve army of the unemployed in the simulation of Marx's model of economic growth**

As correctly postulated by Marx, the relationships in his model do indeed lead to a growth and collapse behavior in the rate of return and profits as capital grows along with a reserve army of the unemployed since new investments are labor substituting. Investment is driven down to zero when both the rate of return and the rate of profit go to zero. Meanwhile, the capacity utilization shrinks and idle capital stock rises.

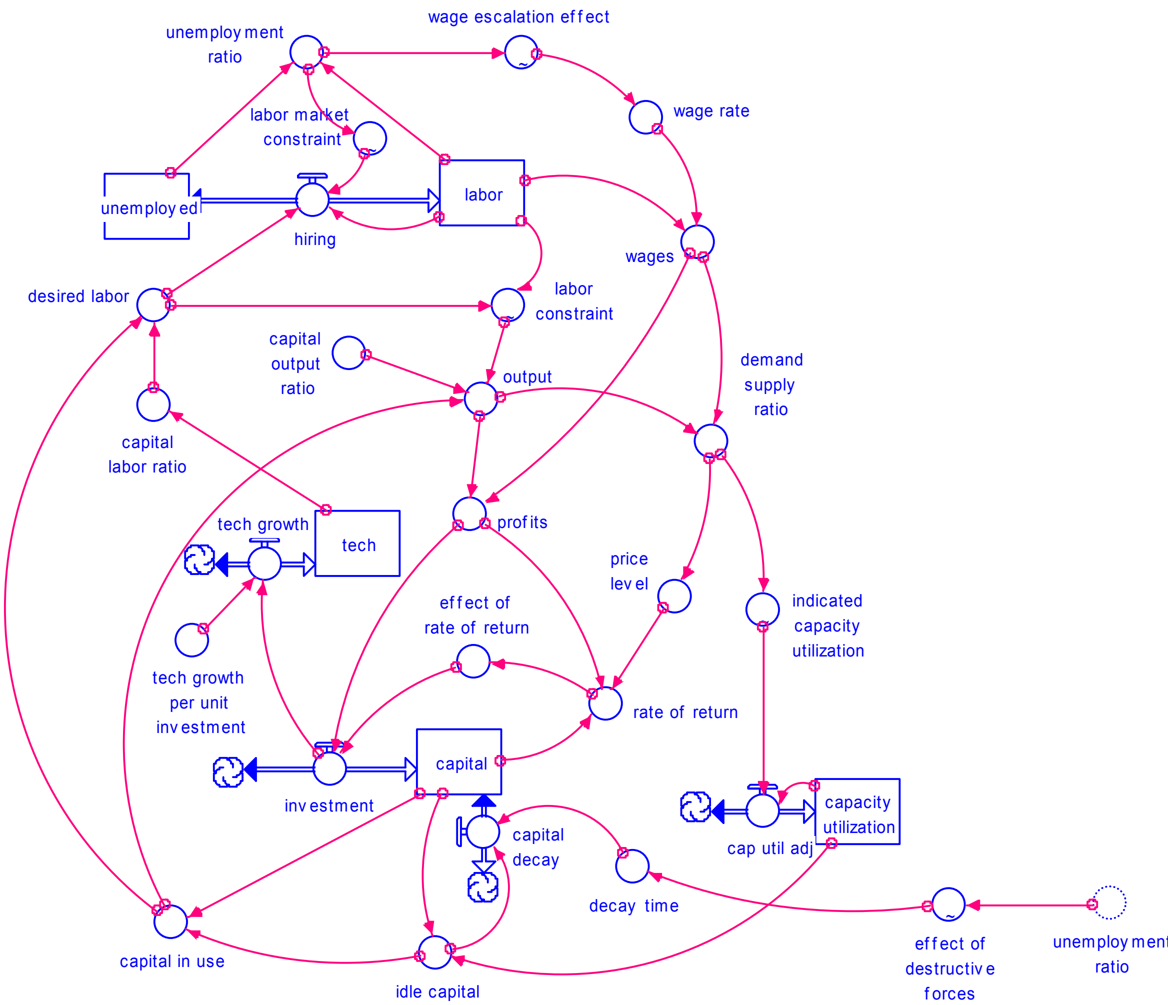

Figure 8a: Capital decay added to Marxian model

The decline in profits is due to the growth in idle capital rather than the wage bill since the reserve army of the unemployed keeps wage rate at subsistence level. This can be a conflictful scenario that Marx suggested signaled the end of capitalism. It is not clear whether Marx thought the reserve army of the unemployed would destroy idle capital (Baumol 1959), although he postulated that the uprising of the masses would be concomitant with such destruction. Either way, the stock of physical capital would decay as suggested by the additional structure in Figure 8a, and the simulated behavior arising from this structure as shown in Figures 8b and 8c. The decay is faster when the destructive forces arising from the reserve army of the unemployed are taken into account and slower without them, but the trend is the same in both cases.

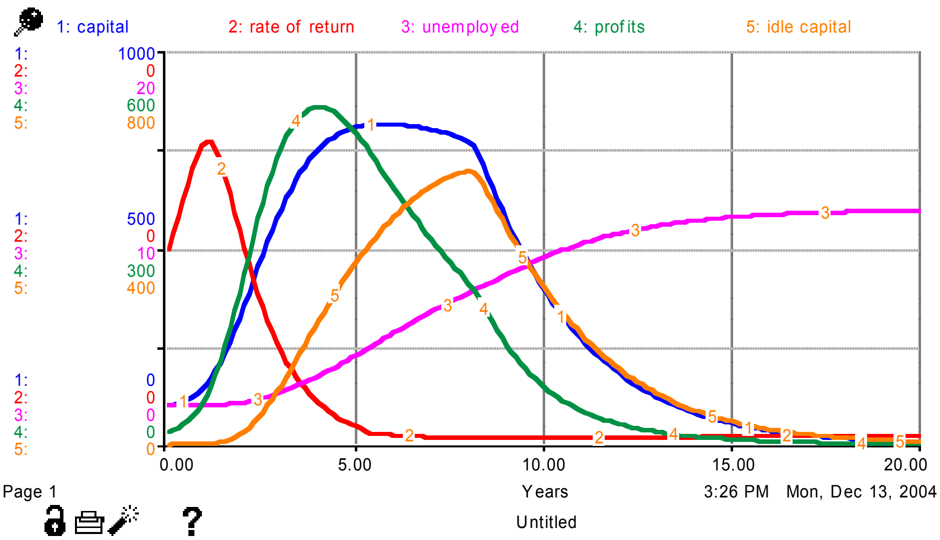

Figure 8b: Decay of capital with a disruptive reserve army of the unemployed

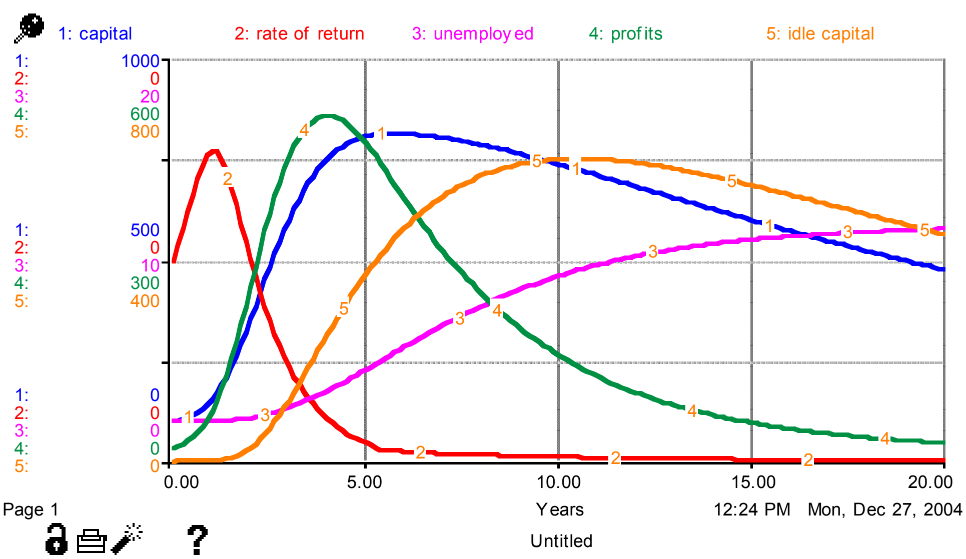

Figure 8c Decay of capital with a peaceful reserve army of the unemployed.

Schumpeter's concept of creative destruction and economic cycles

While Marx's model of destruction of capitalism by an exploited proletariat was based on a class system that locked capitalists and proletariat in separate compartments, Schumpeter saw the possibility that entrepreneurship could exist across all social classes. Thus new entrepreneurs could emerge from the ruins of a fallen capitalist system. They could create a resurgence of capitalism from an environment in which cheap labor and the possibility of profiting from it would allow them to mobilize idle capital resources and create new and marketable goods and services from them. In my observation, Schumpeter saw the possibility of social mobility between classes arising from entrepreneurship that would rejuvenate a declining capitalist economy, while Marx had ruled out such mobility. Schumpeter pointed out that entrepreneurs innovate, not just by figuring out how to use inventions, but also by introducing new means of production, new products, and new forms of organization. These innovations, he argued, take just as much skill and daring as does the process of invention (Schumpeter 1962).

Quoting from Schumpeter's biography:

Innovation by the entrepreneur, argued Schumpeter, led to gales of "creative destruction" as innovations caused old inventories, ideas, technologies, skills, and equipment to become obsolete. The question, as Schumpeter saw it, was not "how capitalism administers existing structures,... [but] how it creates and destroys them." This creative destruction, he believed, caused continuous progress and improved standards of living for everyone (Library of Economics and Liberty: Schumpeter's biography)

Figure 9a shows the production system and labor market structure implicit in Schumpeter's mental model as outlined by Higgins (Higgins 1968, pp 88-105).

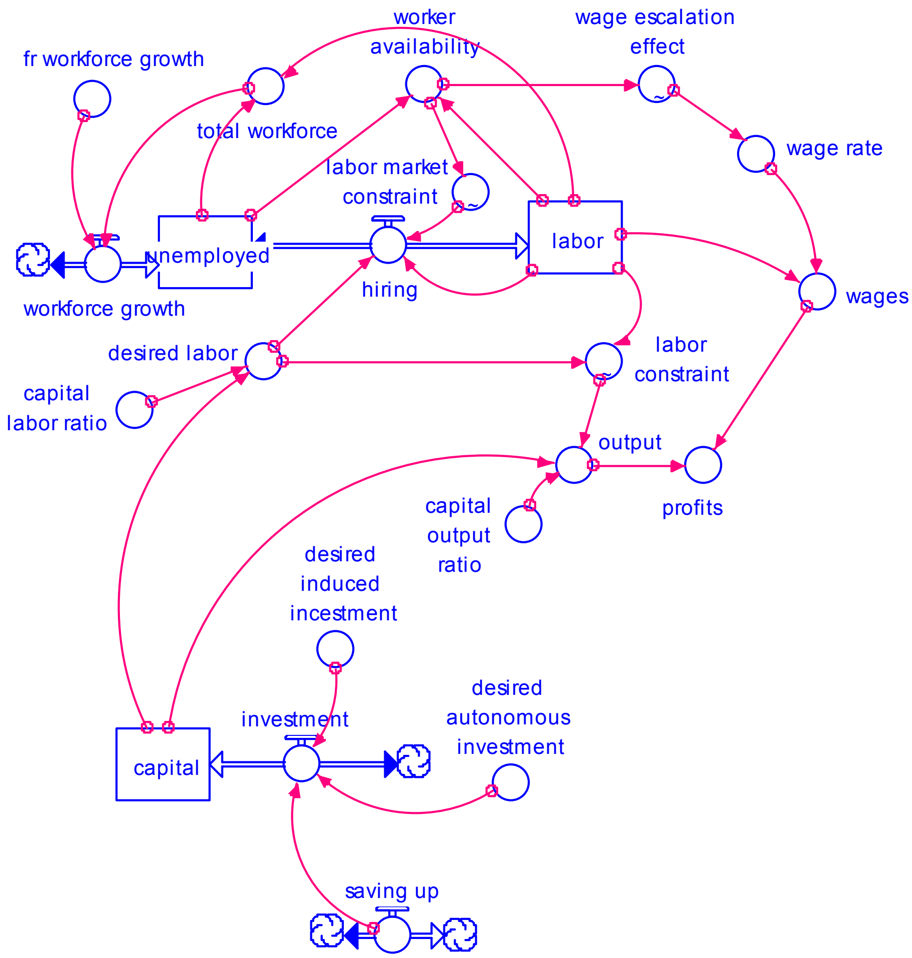

Figure 9a The production system and the labor market implicit in Schumpeter's model.

Please note this structure is more or less similar to the Marxist model with the exception that labor substituting characteristic of technology is omitted and the direct link between profits and investment is deleted. Schumpeter, in fact, distinguished between two types of investment that he called *induced* and *autonomous*. He also introduced a concept of "*saving up*" which is different from saving in the neoclassical growth model. Saving up constituted the part of output that is withheld from investment and consumption. Induced investment arose from the discrepancy between supply and demand and autonomous investment from resources and technology created by the entrepreneurs.

Saving up, possibly extended across social classes and fueled entrepreneurial activity leading to autonomous investment. Although one does not get a clear sense of this process from the descriptive writings of Schumpeter, I detect recognition of social mobility in this concept that allows workers to become the new capitalists. In the complete model shown in Figure 9b, I would make a small amendment to Schumpeter's concept of entrepreneurs creating resources; I would call it mobilizing resources accumulated through saving up.

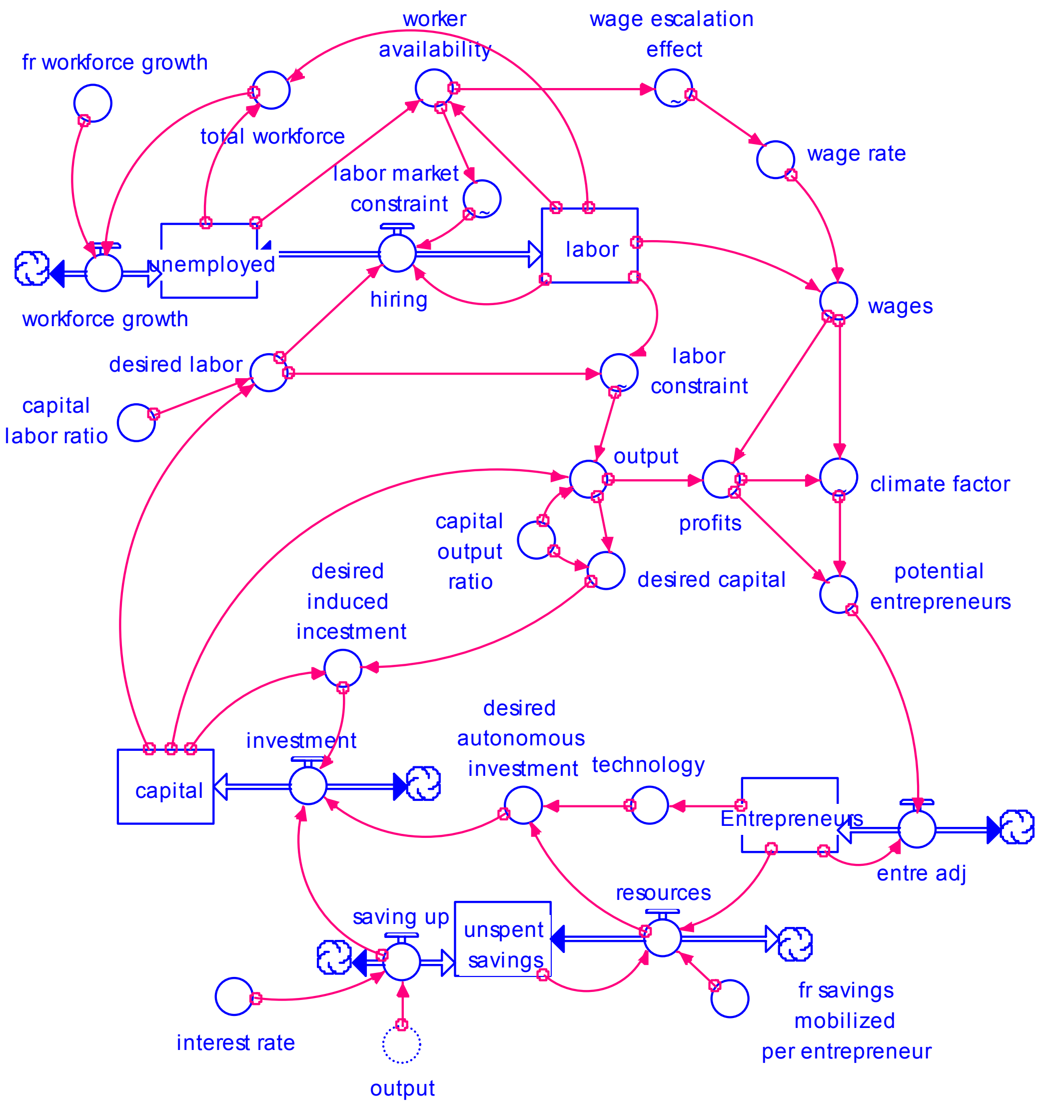

Figure 9b Complete structure of Schumpeter's model of creative destruction

Both mobilized resources and technology depend on the number of entrepreneurs which adjusts towards potential number determined by profits and entrepreneurial climate. According to Schumpeter, entrepreneurial climate is created by the availability of a high rate of profits and the availability of cheap labor. I have accumulated the difference between the saving up, which Schumpeter said depended on interest rate, and the mobilized resources in a stock of unspent savings which supply the venture capital for the entrepreneurs. This also allows the model to have a hypothetical equilibrium in which induced investment is zero and saving up equal the resources mobilized by the entrepreneurs or the venture capital investment.

Figure 9c shows the behavior of Schumpeter's model with a fixed labor supply. Figure 9d shows the behavior with an autonomous rate of growth in labor. The model shows the cycles extensively discussed by Schumpeter, although the variety of periodicities he referred to is not shown.

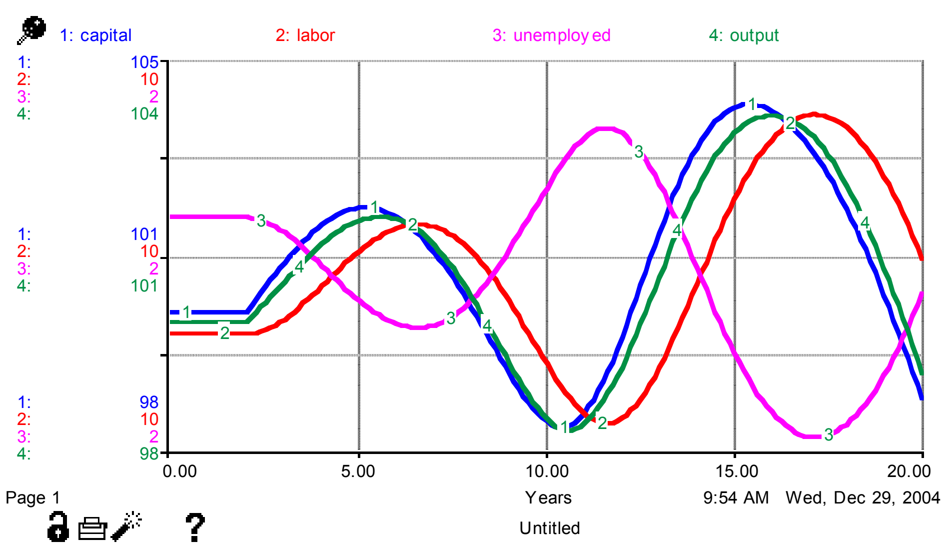

Figure 9c Behavior of Schumpeter's model without autonomous population growth

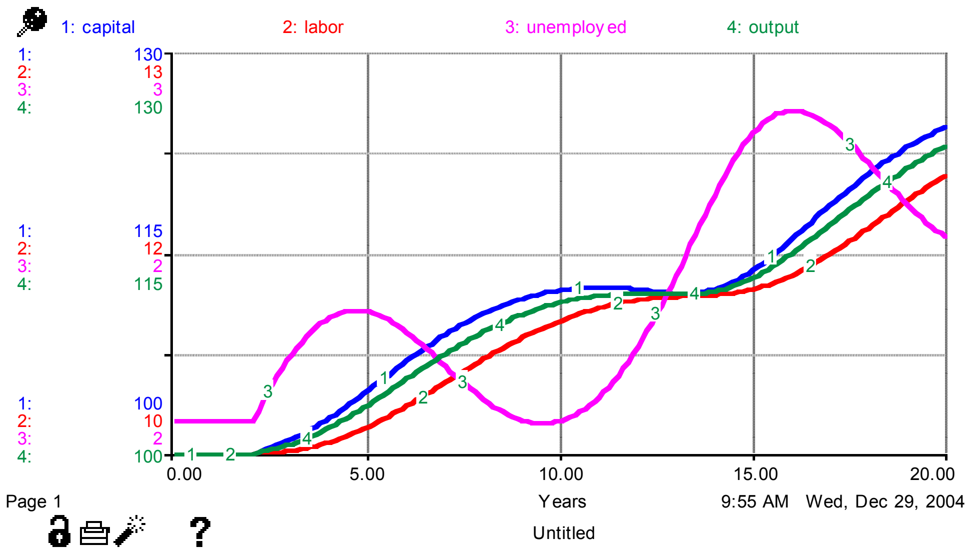

Figure 9d **Behavior of Schumpeter's model with autonomous population growth**

The autonomous investment arising from entrepreneurial creativity creates competition that expands creative activity and shrinks profits, while creating tightness in the labor market that takes away the very elements of the entrepreneurial environment that helped launch it. Schumpeter called this process the "creative destruction" and postulated that this would result in a cyclical tendency in the capitalist system, which is indeed borne out buy the simulation of his model. Although Schumpeter referred to may types of economic cycles in his writings the feedback processes distinguishing their periodicities are not clear. The model I have constructed exhibits a periodicity of about 10 years based on the time constants I have selected, while it specifically addresses the process of creative destruction that Schumpeter originally posited.

Conclusion

The concept of limits was tightly interwoven with the process of growth postulated in the classical theories. These limits encompassed many domains including demographic, environmental, social and political. In most instances, the recognition of these limits required dealing with soft variables that were difficult to quantify in the neoclassical analysis tradition. It is not surprising that these processes have been excluded from the formal analyses of mainstream economics, which has greatly reduced the explanatory power of the neoclassical theory, which has come to attribute all deviations from the postulated behavior of a hypothetical perfect market system to the imperfections in the reality, which is a violation of the scientific principles of modeling. All models are wrong, only reality is right and first requirement of a model is to replicate some aspect of reality before it can be accepted as a basis for a policy intervention.

Classical economics, on the other hand did attempt to replicate empirical realism in its theories often using soft variables in its explications. System dynamics modeling allows reinstatement of such soft variables in our models of economic behavior that should reincarnate the rich insights the traditional economic concepts provided. This indeed requires reinventing modern economics which should be undertaken without further delay.

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