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Money and the Real Economy: A Computational Search for Cantillon Effects

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Abstract

Richard Cantillon's conjecture from 1735, that the particular path by which money is injected into an economy will exert real economic effects, is generally ignored in contemporary monetary analysis, perhaps because it would seem to imply some tradeoff between inflation and unemployment in a natural rate model. In this working paper, Dr. Daley takes a computational approach to economic modeling and develop a formulation whereby the path of monetary injection exerts real economic effects within the framework of a natural rate model. In this computational model, real effects operate through variations in the structural pattern of economic activity, while leaving aggregate magnitudes approximately unchanged. (JEL: D5, E5)

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It is now nearly a quarter millennia since Richard Cantillon (1735) advanced his claim that the particular channel by which money enters an economy can exert significant real effects upon that economy. While a few commentators have noted Cantillon's claim from time to time (for instance, Joseph Spengler (1954) and Oskar Morgernstern (1973)), that claim has pretty much remained becalmed in one of the backwaters of economic scholarship. Current modes of analysis support this backwater location through arguments that monetary effects upon the real economy are transitory at most. Regardless of the path of money injection, the economy reverts to equilibrium after an injection of money. At most, different injection paths might be accompanied by second-order differences in the speed of transition to equilibrium. In any case, the impact of money on the real economy is transitory and not permanent.

This paper seeks to advance what might appear to be two contradictory claims. On the one hand, we accept the central claim of natural rate modeling, whereby deviations between actual and natural rates of output or employment are transitory results of money surprises and not permanent features of a capitalist economy. On the other hand, we argue that it is nonetheless possible for the path of money injection to exert significant effects upon the real economy. The apparent contradiction between these two claims can be reconciled by shifting analytical attention away from the relation between money and aggregate output and directing it toward the relation between money and various structural

features of the economic order.[1] The presence of Cantillon effects does not require the abandonment of natural rate modeling. It requires only that analytical attention be centered on structural features of the real economy, with only second-order implications for measures of aggregate output. In this vein, we develop a model by which different methods of money injection generate different locational patterns of economic activity. While this locational shift shows up as changes in the pattern of land rents, there is no necessary reason for any change in the average price of land relative to the average price of other goods. Moreover, actual output equals natural output across the institutional settings, thus conforming to common notions of neutral money, and yet monetary institutions have real consequences. Following this presentation, we set forth a computational effort to convey such ideas. In so doing, what comes into sharper focus is awareness that monetary arrangements might exert deeper and stronger effects upon the real economy than is implied by models of near-neutrality, even if those arrangements have little or even no effect upon measured aggregate output.

What Real Consequences of Monetary Injection?

In his *Essay on the Nature of Commerce in General*, Richard Cantillon advanced some illustrations of his argument that the manner in which money enters an economy can affect the real substance of economic activity. For

[1] In this, our analysis perhaps bears a family resemblance to Edmund Phelps' (1994) focus on structural features, only he was concerned with the structure of deviations of actual from natural output and we are concerned with changes in structure even though actual output equals natural output in the aggregate.

instance, Cantillon distinguished between an increase in money that originated from the mining of gold or silver from an increase that originated from a favorable balance of trade. These different processes of monetary injection created different chains of transactions, with, in Cantillon's view, the real pattern of economic activity being influenced by the particular process of monetary injection. In making this formulation, Cantillon denied the simple quantity theory proposition that an increase in the quantity of money will exert the same proportionate effect on prices regardless of how that money is injected into the economy. In Cantillon's view, different channels of monetary injection would exert different effects on the pattern of prices, leading in turn to different patterns of real economic activity. For instance, if money is injected at points where the recipients have particularly high demands for goods in relatively inelastic supply, those particular prices will rise further than they would under some alternative locus of monetary injection. Cantillon's claim is that the vector of market prices will generally differ, depending on the particular process or path of monetary injection.

While Cantillon's claim was echoed occasionally in the ensuing years, it found its strongest support in the Austrian-style analyses associated originally with Ludwig von Mises (1934) and Friedrich Hayek (1932)(1935). The Austrian-style analyses emphasize the non-neutral character of monetary expansion, with the specific details depending on the particular path by which money enters the economy. In the original formulations by Mises and Hayek, money was thought to enter through the extension of credit to commercial enterprises. What resulted

was an ultimately uneconomical and nonsustainable expansion in the output of enterprises involved primarily with the production of capital goods. Other paths of monetary injection are easy enough to imagine within this general orientation. For instance, money could be injected through government transfer programs, as Roger Garrison (2001) notes. At its most general level, the Austrian-style analysis on behalf of Cantillon effects is simply that the pattern of real activity within an economy will be influenced by the method by which or path through which money is injected into the economy.

There are, however, two distinct senses in which money injection paths might influence real economic activity. Contemporary analysis, including the Austrian-style analysis has focused exclusively on one of those senses, while Cantillon's formulation was in terms of the other sense. The contemporary formulations of neutral money are thus orthogonal to Cantillon's formulation. It is thus possible to accept a Cantillon-like formulation about the non-neutral character of money injection paths while at the same time accepting a natural rate-type formulation about the near-neutrality of money injection paths in the aggregate.

What does it mean to claim that money injection paths exert real economic effects? There are two distinct ways to formulate this type of claim: the common way and Cantillon's way. The common way follows from the hypothesis that there is a direct relationship between changes in money and changes in aggregate economic activity. In this, both the Austrian-style and the monetarist-style analytics take the same approach in seeking to relate monetary change to

subsequent changes in aggregate output. To be sure, there are significant differences between these two approaches. In the monetarist approach, monetary change induces a temporary deviation of actual from natural output, followed by a reversion to natural output. In the Austrian-type approach, the reversion to natural output is preceded by an oscillation, where there is both a period where actual output exceeds natural output as well as one where it falls short of natural output. [Friedman, Garrison on "Plucking model"?] What is most significant, however, is that the analysis treats neutrality in terms of the relation between monetary change and a deviation between actual and natural rates of aggregate output.

The claim that the real consequences of monetary expansion might differ across monetary institutions or arrangements has not fared well within contemporary monetary analysis. This is true even among those who otherwise have expressed some interest in Austrian-style analytics, as illustrated by Tyler Cowen (1997). The reason for disinterest in Cantillon-type effects is illustrated clearly by the standard natural rate formulation where a money surprise can create a temporary divergence between the actual and natural rates of output.

It is, however, possible to accept the general features of the natural rate model while still entertaining the claim that the path of money injection can exert significant real effects. This claim on behalf of Cantillon effects is distinct from claims about monetary surprises within a natural rate model. The distinction arises because Cantillon effects operate through changes in the structural pattern of economic activity. Cantillon effects alter the pattern of economic

relationships that comprise the aggregate set of economic relationships. Monetary surprises within a natural rate model expand or contract the entire economic nexus without disturbing the relationships among the individual elements that constitute that nexus.[2]

Here, we examine the possibility that alternative monetary arrangements can exert permanent effects upon the structural pattern of economic activity, even if they might leave undisturbed an underlying tendency toward equality between natural and actual rates of output. This occurs through money-induced changes in the relationships among the elements that constitute what is measured within aggregate output. The natural rate formulation, whatever may be its value in other contexts, is not equipped to deal with Cantillon effects because economic structure is irrelevant to that formulation. This situation can be remedied, of course, and to start in this direction is our aim here. The central point in any case is that the search for Cantillon effects must focus on possible changes in the pattern of economic activity and not on possible changes in some measure of aggregate activity. While monetary changes might well generate changes in aggregate measures of economic activity, the key to possible Cantillon effects resides in changes in the structural relationships that constitute that measure of aggregate activity.

[2] To be sure, in the Austrian-style analytics there is a temporary shift in the structure of economic relationships that comprises the expansion and contraction in the overall economic nexus. In particular, monetary expansion is accompanied by a shift in the structure of relative output toward producer goods.

Monetary Injection, Location, and Economic Structure

Whether or not aggregate output tends toward some natural rate and whether or not processes of monetary injection influence the pattern of real economic activity are independent questions. Our concern here is with Cantillon effects and not with the natural rate model. This concern does not require us to abandon a natural rate model, but rather requires us to adopt a formulation where economic structure is primary and constitutes the raw material from which the economic aggregates are generated, a theme that is developed with particular clarity in Joshua Epstein and Robert Axtell (1996). Cantillon effects are not detectible in terms of some systematic deviation between actual and natural output. What is involved rather is the claim that the real pattern or structure of economic activity may vary with variations in the institutional arrangements that govern monetary expansion.

Any effort to treat the relationship between monetary institutions or injection paths and economic structure must confront the plethora of both monetary institutions and the components of economic structure. To simplify our exposition, we treat but two institutional arrangements and focus on but one component of economic structure. With respect to institutional arrangements, our modeling effort bears some resemblance to the distinction between central and free banking, though this paper does not involve any effort to compare actual banking institutions, but rather is concerned only to set forth a framework for conceptualizing money injection paths in a manner that is amenable to computational modeling. Hence, we compare two methods of money injection.

With one method, all new money enters the economy through one particular node within the economic nexus. We describe this setting as one of central banking, despite its descriptive inaccuracy. With the other method, money enters simultaneously at all nodes within the economic nexus, and in proportion to the money balances held at each of those nodes. We describe this setting as free banking, again despite its descriptive inaccuracy. Indeed, this form of money injection could be assimilated to a framework of central banking. All that would be necessary would be for proportionate increases in each agent's average monthly balances, accompanied by the necessary purchases of government debt by the central bank. Our interest, though, is only to sketch a framework for modeling how different paths of money injection might have real economic consequences, and to instantiate this model computationally.

The model we sketch below treats monetary institutions as differing in their geographical pattern of injection. There are other ways in which monetary institutions could support different patterns of injection. For instance, they could operate so as to inject money through established, perhaps relatively large enterprises, or they could operate so as to inject money through new or nascent, relatively small enterprises. Alternatively, they could operate to inject money through consumer rather than enterprise channels, as perhaps through government transfer payments.

By geographically based injection, we treat people and their economic activities as locationally specific. In one model, money enters the economy in concentrated fashion through one particular node within the economic nexus. In

the alternative model, money enters in decentralized fashion through all nodes within the economic nexus. The standard quantity theory analytics holds that money injection leaves real equilibrium undisturbed regardless of the path of injection, even though there might be a transitory disturbance. The reason for this is that money is diffused throughout the economy regardless of the injection process. A puff of polluted air will become geographically diffused through the operation of air currents, and the quantity theory model generates the same outcome for the diffusion of money regardless of the concentration at its point of points of injection.

There is, however, a difference between pollution and money. Polluted air is moved about by air currents. The extent to which money is diffused depends on the actions people take. Those who occupy the points of injection are faced with an excess supply of money. They want to reduce their money balances, and there is an excess demand for those balances on the part of potential claimants. Credit transactions of various types shift the holdings of those money balances. The cost of monitoring credit transactions will influence the diffusion of money. In this process, informational distance matters. The recipients of new money seek to dispose of their excess money holdings, and to some extent will do so by extending credit. Suppose that, ceteris paribus, the cost of monitoring credit transactions rises with the distance between borrower and lender. If so, geographically based injection could be expected to exert some long-run shift in the location of economic activity. Commercial locations relatively close to those nodes where money is injected particularly heavily will become more desirable

relative to more distant locations. Hence, land rents and population densities will rise in those places. Under either monetary arrangement, actual output may tend to equal natural output, and yet there would be significant real differences due to differences in monetary organization. Those differences, however, would appear not through deviations between actual and natural output but through differences in the geographical location of economic activity.

A Computational Framework for the Analysis of Cantillon Effects

We have developed a small computational model in C++ to illustrate the possible operation of Cantillon effects (and have received much inspiration in doing so from Peter Howitt and Robert Clower (2000)). This model concentrates on geographically based injection. We compare a simple two-region model as it operates within two distinct institutional frameworks for monetary injection. One framework entails what we have labeled helicopter injection, and involves equal rates of injection in each region. The other framework entails exclusive monetary injection through one of the regions. Initially, both regions are economically identical, and we explore whether discernable real differences emerge as between the two distinct institutional frameworks for nominal money injection.

We denote our regions as C and P, perhaps as corresponding to notions of Center and Periphery. To be sure, this distinction has no impact in our baseline model, as in that model it would represent the arbitrary construction of a dividing line across a uniform plain. The distinction between regions is something that arises only after there has been an institutional shift away from

helicopter-like injections of money to a location-specific point of injection. In that initial model, C and P each contain one bank, ten firms and one hundred worker-consumer agents. Each individual actor is perfectly homogenous, save for the region in which each actor lives. Throughout the running of the model, only the agents have the option to relocate. Whether relocation occurs depends upon the potential wage the consumer-worker can garner; which will be explicitly stated in the rules of agent behavior. The rules that each class of agent's adhere to are as follows:

Bank: Each period a bank has a sum of money, which it then makes available in equal shares to the firms within its own region.

Firm: Each firm is constrained financially. In conjunction with the wage the firm is offering to potential employees, the firm's available funds determine the maximum, or in our simple case, optimal number of employees. As the available funds increase the firm expands the scale of its operations and thus seeks to expand employment, and will raise it's offer wage to fill any vacancies. Of course the firms will, while following this simple rule, contract in the face of a shrinking fund base.

Consumer-Worker: Each period the ordering of the agent initialization is shuffled to remove the possibility of a first-mover advantage for any particular agent. So each round every agent once activated randomly selects a firm with an employment opportunity. The agent will consider moving to this firm dependent upon the region and offered wage. In the case of a firm in the same region, if an offered wage is higher than the worke's current wage, the agent will always

move. If, however, the offering firm wage is higher but it is in the other region, the difference must be greater than some threshold to adequately compensate the agent for moving regions. These two scenarios are analogous to a worker weighing two different employment opportunities. Let us say that two employment opportunities exist, both offering the same higher wage. One is in the same region as the agent while the other is not. All other things being equal the agent will discount the higher wage in the other region, as there are costs to changing residence. Therefore, for a wage in the other region to be as equally attractive it must be higher than some threshold, which the agent believes adequately recompense them for relocation.

Initialization of the Model

The banks in C and P are given the same amount of money and each agent is given a wage of zero and has no current employer. Economy theory would suggest that a stable and roughly equal population mix (1:1) would emerge with the wages of both regions being comparable. That is indeed what we find. As each firm seeks to fill its workforce and as all agents are seeking jobs, there is some interregional relocation in the early rounds but this soon settles down until only intra-regional moves (changes in employer but not residence) are occurring.

The results of various monetary arrangements

With this model as our basis of economic interaction we now introduce our baseline of monetary intervention. Helicopter money is injected evenly into the economy through the banks. The previous level of available funds is increased

by some factor and the banks of C and P each receive an equal share of the increase, which is then made available to their local firms. Due to the randomness of the search and order of agent activation this increase in available funds to the firms does induce some short-run interregional migration. Workers move to their highest wage (if the threshold of interregional moving has been passed) to the other region or simply switch between local firms as offered wages offer improved earnings. Within three to four periods (on average) this simple economy has stabilized with a population mix once again approaching a ratio of 1:1. The corollary of higher wages bears out current macroeconomic thinking. The helicopter injection stimulated the simple economy in that firms sought to expand output and offered higher wages to entice workers to fill their vacancies. In the simple model without a monetary injection the wage over multiple runs approaches 170 monetary units. The impact of the helicopter injection raises the wage, in both regions, by a scalar with matches that of the monetary increase. For example, when the money supply is increased by as much as 50% the wage rises until it reaches a new average of roughly 255. This holds also for much smaller rates of change, although if the increase in the money supply is less than the discount rate employed by agents in comparing other region wages with their current region wages, this leads to almost no interregional movement. Nonetheless, the wage inflation still matches the increase in the money supply. As noted previously, however, we are not attempting to deal with money surprise modeling per se but rather with illuminating how new ways of modeling might increase our understanding of

differing monetary arrangements. As such, the wage inflation evident in our helicopter money expansion is merely secondary to the change in population mix across the two regions.

To examine the possible ability of the institutional means of monetary injection to exert real economic effects within a society, we run our simulation again with all money being injected through a central bank located in region C. Moreover, we examine two types of concentrated money injection. One type is a continuing injection, where new money is injected continually into the economy at C. The other type is a one-shot injection of new money at C. With the one-shot injection, money diffuses throughout both regions after about five rounds.

With continuing injection in C, the pattern of economic location between C and P changes for for two complementary reasons. The relative wages of the two regions will initially diverge rather than converge as firms in C expand employment opportunities and raise their offered wages in an attempt to fill these newly created vacancies. While in an attempt to fill their own vacancies the firms of P while scaling back their workforce are induced to offer higher wages to keep a smaller workforce (in comparison to C) due to the expansionary activity in C. In consequence, location patterns and population density will change in response to the change in the institutional framework for monetary injection. In fact one could easily imagine that if a mechanism for land rents were included in the model, this too would reflect a similar pattern as we have seen with the changing population density. The continuing injection yields a population mix of almost 7:3. As such the bulk of the population is now living and working in C. When the change in firm

fund provision is maintained at dissimilar levels, it is not surprising to find that the change in population density is now stable at a rate that is significantly different from our helicopter example.

What then of the one time injection? The initial impact is basically the same as described for the continuing injection: workers from P move to C leaving C with a significant majority. Once the regional money supply begins to equilibrate, C's expansion becomes a contraction while P experiences some expansion. This shifting between regions continues until the population density settles at 5.7:4.3. A much smaller shift in the distribution of population results than resulted with continuing injection. Nonetheless, the resulting population distribution is still significantly different from 1:1. A one-time injection, while it enters and then seemingly vanishes through diffusion, has the ability to bring about a permanent change.

One avenue of inquiry that has not been as thoroughly explored as the above is the perturbing of this permanent effect. For example, in some brief runs, it appears that a helicopter injection has the potential to drive the population density back to 1:1. This effect does not happen immediately, and more testing is required, but it would not be surprising given what we have discovered thus far.

Concluding Remarks

This paper has not shown that Cantillon effects are truly significant, nor has it sought to do so. What it has tried to do is to present an analytical framework within which the operation of Cantillon effects could be explored.

(Testatsion) Standard aggregate models are inappropriate for the examination of such effects because they are not equipped to deal with the structural shifts that Cantillon effects represent. In looking for Cantillon effects, one must not look to the comparative statics of monetary or macro aggregates. Instead, one must look to the structural composition of economic activity, and particularly within an analytical framework that can accommodate unidirectional development in place of comparative statics.

It would be interesting if such an approach to modeling could lead eventually to some form of what might be called "big picture nonneutrality." For instance, might injection through commercial channels, which was the 19th century norm, reinforce some type of capitalist ethos, whereas injection through transfer payments reinforces some form of entitlement ethos? Just now, this line of analysis seems to be a bit of a stretch, but further examination might show otherwise. What is intriguing in any case is the possibility that such an approach might place monetary arrangements more onto the center stage within a society, whereas monetary arrangements are pretty peripheral within the various super- or even near-neutrality varieties.

References

Axtell, Robert (2000). "Why Agents? On the Varied Motivations for Agent Computing in the Social Sciences." In C.M. Macal and D. Sallach, eds. *Proceedings of the Workshop on Agent Simulation: Applications, Models, and Tools.* Argonne National Laboratory: Chicago, Il, pp. - .

Cantillon, Richard (1735). *An Essay on the Nature of Commerce in General*. Henry Higgs, ed. (London: Macmillan, 1931).

Cowen, Tyler (1997). *Risk and Business Cycles: New and Old Austrian Perspectives*. London: Routledge.

Epstein, Joshua M. and Axtell, Robert. (1996) *Growing Artificial Societies: Social Science from the Bottom Up*. Washington: Brookings.

Friedman, Milton (1993). "The 'Plucking Model' of Business Cycle Fluctuations Revisited." *Economic Inquiry* 31: 171-77.

Garrison, Roger W. (2001). *Time and Money: The Macroeconomics of Capital Structure*. London: Routledge.

Garrison, Roger W. (1996) "Friedman's 'Plucking Model;' Comment." *Economic Inquiry* 34: 799-802.

Grossman, Herschel ( ) [review article on Handbook of Monetary Economics]

Hayek, Friedrich A. (1932). *Monetary Theory and the Trade Cycle*. New York: Harcourt Brace.

Hayek, Friedrich A. (1935). *Prices and Production*, 2nd ed. London: Routledge and Kegan Paul.

Howitt, Peter and Clower, Robert (2000). "The Emergence of Economic Organization." *Journal of Economic Behavior and Organization* 41: 55-84.

Leijonhufvud, Axel ( ) Wicksell Connection

Mises, Ludwig von (1934). *The Theory of Money and Credit*. London: Jonathan Cape.

Morgernstern, Oskar (1973). "Thirteen Unsettled Problems in Economic Theory." *Journal of Economic Literature* : xx-xx.

Patinkin, Don (1965) *Money, Interest, and Prices*, 2nd ed. New York: Harper & Row.

Phelps, Edmund S. (1994) *Structural Slumps: The Modern Equilibrium Theory of Unemployment, Interest, and Assets*. Cambridge: Harvard University Press.

Potts, Jason (2000). *The New Evolutionary Microeconomics*. Cheltenham, UK: Edward Elgar.

Selgin, George (1988). *The Theory of Free Banking*. Totowa, NJ: Rowman & Littlefield.

Spengler, Joseph J. (1954) "Richard Cantillon: First of the Moderns." *Journal of Political Economy* 62: 281-95, 401-24.

Tesfatsion, L. (2002) "Agent-based computational economics." ISU Economics Working Paper No. 1, Iowa State University Economics Department.

White, Lawrence H. (1999) *The Theory of Monetary Institutions*. Oxford: Blackwell.