A Model of Austrian Economics

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Abstract

This paper presents a formalized synthesis of Austrian and Post-Keynesian economics. The model is agent-based and accounting-based and is implemented in Java. The agents are categorized as households, firms, and banks and they exchange goods and services against money on virtual markets. Each agent’s economic activity is registered by a balance sheet. A stock-flow consistent accounting framework monitors the transactions between these balance sheets and records the emergence of macroeconomic patterns. The model is in a state of disequilibrium at all times, i.e. the price of a good is not unique and markets do not clear. Rather, each agent who offers a good or service sets the respective price based on an algorithm that evaluates the current market situation from his own perspective (procedural rationality). Price setting is speculative, since all agents are subject to knowledge constraints and radical uncertainty. The modeled economy has multiple types of goods which are produced in accord with the investments of the firms. The resulting capital structure is the result of consumer preferences and the technological possibilities of the firms. Firms which are unable to serve their credit obligations have to file bankruptcy and are replaced by new firms. This way the economic system gains the flexibility that is necessary to adapt to changing conditions. It is thus possible to show how a change in preferences alters the production structure of the economy and how this is reflected in the system of national accounts. Moreover, a manipulation of the rate of interest will lead to allocations that are in incongruence with the preferences of the households.
1 The model in a nutshell

The model which will be proposed in the following is constituted by a multitude of agents who act in a given environment. The agents are categorized as households, firms, and banks. Between these agents there are well-defined property relations. Every good and every company that exist in the economy is always owned by a certain agent. The agents trade with each other on virtual markets and they enter contractual relationships. There is a universal universal medium of exchange called money which facilitates these interactions. Each agent has a balance sheet which monitors these interactions and keeps a detailed account of the agent’s property and financial agreements.

All economic activity in this model is borne by the decentralized actions of the agents. The firm agents use their funds to purchase fixed capital goods, intermediate capital goods, and labor and they use these inputs to produce goods. The households, on the other hand, buy goods and consume them and the banks act as financial intermediaries between households and firms. When firms or banks offer a product for sale a market comes into existence. A market always consists of a list of offers which all specify a quantity and a price. The purchasers of goods then consult a certain number of these offers, choose the one with the lowest price, and subsequently evaluate whether a purchase would improve their economic condition. If it is rational for them to buy the product they pay the necessary amount of money to the offerer and receive the good in exchange. Otherwise, they decline the offer.

The actions of the agents are motivated by certain pre-defined goals. Since all agents operate under uncertainty and have limited knowledge about market conditions, they apply algorithms of procedural rationality in order to achieve these goals. In these algorithms the agents evaluate the economic situation from their own perspective and plan an action which seems to optimally serve their purposes. The producers of goods, for instance, set their asked price to the level which they deem revenue maximizing according to their own
market experience. Similarly, firms make an investment if their experience suggests that it is profitable to do so. The difference between households and non-households in this context is that households evaluate profitability under utility considerations whereas firms and banks make monetary gains the basis of their decisions. The decision algorithms of the agents introduce behavioral elements into the model which will be further explored in the Sections 3, 4, and 5. The following section deals with the formal setup of the model. Section 6 then elaborates on the functioning of the model. Section 7 provides a discussion.

2 The setup of the model

2.1 Physical capital

The capital structure of the economy is modeled as a grid in which each node represents one type of good (Figure 1). The horizontal layers of the grid are conceived as stages of production. That is, the top layer represents consumer goods while the lower layers represent goods of higher order. The different nodes in each layer, which are labeled in alphabetical order, display the variety of goods within a certain stage. Type A goods are durable goods which can be used as machines. These goods constitute the fixed capital of firms. The other goods are either consumer goods or intermediate capital goods. The difference between intermediate capital goods and machines lies in the fact that the former are fully used up in the production process while the latter only wear out over time. The life span of machines is assumed to be identical for all machines. All goods are assumed to be non-perishable and can be stored until they are sold. The firms have no direct use for their products. They produce goods only for the purpose of selling. Moreover, firms only buy goods in order to use them for production. Finally, the households
consume all their purchases at the end of each time period.

Each firm can only produce one type of good and thus chooses a node at which it operates. Depending on where in the system a firm operates the types of good that it can use as inputs will vary. As fixed capital the firms can only use type-A goods of their own stage. And as intermediate goods the firms can only use goods from the next higher stage of production and among those only goods of the same or a neighboring type. For example, a firm which produces the good C2 can use goods of type B3, C3, or D3 as intermediate inputs. Furthermore, the firm may use the machines of type A2. The products of the firm can be used by other firms who operate at the nodes B1, C1, or D1 (Figure 2).

In order to produce goods the firms have to use labor, i.e. no output can
be generated using capital alone.$^1$ In addition, firms can optionally use capital goods in order to enhance their productivity. Without loss of generality it is assumed that each worker can produce one product per time period when working without capital. Furthermore, it is assumed that each worker can process one intermediate good per time period when working without machines, no matter where on the grid he operates. When using machines, however, the capacity of workers to process intermediate goods increases. One may thus define a quantity called effective labor $\hat{l}$. This quantity describes the number of intermediate goods that can be processed with a given number of workers and machines.

Formally, the production function of the firms is a fixed-proportions produc-

$^1$The factor land remains abstract in this model. However, one may think of firm owners as land owners so that dividends contain a rent component.
tion function $f : \mathbb{N}^3 \mapsto \mathbb{N}_0$ which can be written as

$$f(l, x, k) = y = pr_x \cdot \min\{\hat{l}, x\} + \left\lfloor \frac{\max\{\hat{l} - \min\{\hat{l}, x\}, 0\}}{1 + pr_k \log_{10}(1 + \frac{k}{\hat{l}})} \right\rfloor$$

with $\hat{l} = l \cdot \left\lfloor (1 + pr_k \log_{10}(1 + \frac{k}{\hat{l}})) \right\rfloor$

and $pr_x \geq 3$, $pr_k \geq 4$.

(1)

Here, $y$ denotes the number of goods produced and $k, x, l$ are units of fixed capital, intermediate goods, and labor, respectively. The constants $pr_x$ and $pr_k$ are productivity coefficients which represent describe the gains that can be reaped from the use of capital and the division of labor. In order for those gains to be positive the productivity coefficients have to be greater than the given lower bounds. The symbol $\left\lfloor z \right\rfloor$ indicates that a number $z$ is rounded down.

This production function is in perfect agreement with the law of returns as stated by Mises (2008, pp.127). When keeping the input of two of the production factors constant then there exists an optimal input level for the third factor. If one deviates from this level in either direction the average productivity of the factors falls. Moreover, equation (1) exhibits constant returns to scale and increasing returns to capital intensity. And finally, this function incorporates an insight that has already been formulated by Adam Smith (Wealth of Nations, pp. 266 - 67), namely that “every fixed capital is both originally derived from and requires to be continually supported by [...] circulating capital. [...] No fixed capital can yield any revenue but by means of [...] circulating capital”.

Not every type of good will always be produced. Only if a firm settles at a certain node will goods of the respective type come into existence. A node can be populated by a number of firms, which introduces competition between these producers. Furthermore, one should note that firms at the highest stage of production will always produce without capital. Hence, there is
also always a possibility to raise the productivity of these firms by providing capital goods to these firms.

2.2 The financial system of the economy

The modeled economy operates under a perfect gold standard. Gold is thus the universal medium of exchange and it represents what Mises (2008, pp.429) calls “money proper”. This money is assumed highly but not infinitely divisible the smallest unit being one grain (1 gr.). The quantity of gold that it exists in the economy is fixed. All physical gold is held by the banks because every non-bank agent has its gold safeguarded by a bank. The banks do not lend these deposits to third parties. Such deposits are kept in checking accounts and are at the depositors’ disposal at all times. These deposits do not bear interest. All monetary transactions are conducted via checks which transfer claims to gold from one party to another. A transaction that occurs between parties who are clients of different banks implies that gold is physically transferred from one bank to another. These deposits are thus money substitutes, they are sight deposits and are thus equivalent to cash (cf. Mises, 2008, p.430).

The households may also transfer their money from a checking to a savings account. Savings are time deposits with a contracted duration and interest rate. The interest payment consists in the difference between the amount of money deposited and the amount of money paid back. In the model all saving contracts are standardized to amounts of 100 grains redemption payment. With an interest rate of $r_s$ and a duration of $T$ months the price of 100 grains future money is thus given as

$$p = \frac{100}{(1+r_s)^T} \text{ grs.} \tag{2}$$

Each household may entertain several savings accounts, also with banks which do not manage his sight deposits. The banks, in turn, can use the
saved money to make loans. As a simplifying assumptions, all loans that the banks grant are installment credits with equal periodic redemption payments. When a loan contract is signed money is transferred from the originating bank to the checking account of the firm. For the bank this transaction constitutes a change on the asset side of its balance sheet, i.e., cash is substituted for an equivalent receivable amount. At the same time the firm lengthens its balance sheet by this amount and incurs the corresponding liability. The balance sheet of a representative bank is shown in Table 1. The money holdings of the bank are balanced by the checking and time deposits on the liabilities side. Moreover, the book value of the outstanding loans appears as a receivable amount. The excess of assets over liabilities corresponds to the bank’s equity. With every installment that a firm pays the bank’s asset and the firm’s liability are reduced by the redemption content of that installment. Since interests are only paid on outstanding amounts the interest payment are relatively high in the beginning of a credit contract contract and they become smaller towards the end. For a loan over $D_0$ grains with a duration of $T$ months and a monthly interest rate $r_d$ the monthly interest and installment are given as

$$int_t(D_0) = r_d D_0 \cdot \frac{T - (t - 1)}{T}$$

$$inst_t(D_0) = int_t(D_0) + \frac{D_0}{T}$$

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2Both savings and loan contracts are loan contracts in the sense that the availability of the deposit is fully transferred from one party to another (cf. Huerta de Soto, 2009, Ch.1).

3In the present state of the model there are no consumer credits. The firms also do not engage in financial investments.
Table 1: Representative balance sheets for the different types of agents. The symbols represent the economic variables as follows: $M$: money proper, $M^h, M^f$: sight deposits, $S$: time deposits, $D$: debentures, $E^f, E^b$: equity, $IN$: value of inventories, $K$: value of fixed capital.

<table>
<thead>
<tr>
<th>Households</th>
<th>Firms</th>
<th>Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M^h$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Worth</td>
<td>$M^f$</td>
<td>$E^f$</td>
</tr>
<tr>
<td>$S$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$E^f$</td>
<td>$IN$</td>
<td></td>
</tr>
<tr>
<td>$E^b$</td>
<td>$K$</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Money transactions in the economy. The columns represent the current account of each sector. Minus signs indicate money outflows and plus signs indicate inflows.

<table>
<thead>
<tr>
<th></th>
<th>Households</th>
<th>Firms</th>
<th>Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption</td>
<td>$-C$</td>
<td>$+C$</td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$+W$</td>
<td>$-W$</td>
<td></td>
</tr>
<tr>
<td>Capital Investment</td>
<td></td>
<td>$+I - I$</td>
<td></td>
</tr>
<tr>
<td>Saving</td>
<td>$-Sav$</td>
<td></td>
<td>$+Sav$</td>
</tr>
<tr>
<td>Redemption</td>
<td>$+R_s$</td>
<td>$-R_d$</td>
<td>$+R_d - R_s$</td>
</tr>
<tr>
<td>Interest</td>
<td>$+rS$</td>
<td>$-rD$</td>
<td>$+rD - rS$</td>
</tr>
<tr>
<td>Dividend</td>
<td>$+Div_F + Div_B$</td>
<td>$-Div_F$</td>
<td>$-Div_b$</td>
</tr>
</tbody>
</table>
Besides the management of liquid funds each firm keeps a detailed account of its inventories. The firms register each of their unsold goods in combination with the investment expenditures that are allocable to its production (see Section 2.2). The sum of these historical costs constitutes the book value of inventories that appears in the firm’s balance sheet. The oldest goods are always sold first.

Any good that a firm produces or acquires is subsequently activated at historical costs in the firm’s balance sheet. Thus, since the model abstracts from non-investive costs, the book value of each produced good precisely equals the amount of money that was spent on the labor and the intermediate goods which were used for its production. Likewise, any newly acquired fixed capital is activated at its purchasing price. While fixed capital is written off according to a linear depreciation plan whose length corresponds to the physical durability of machines the writedown of inventories only happens when they are sold. For the solvency of the firm it is thus immaterial whether it sells all goods at once or whether some goods remain on stock for a while. If the money received in exchange for its products is greater than the total costs the firm makes a profit. This surplus can be paid out to the owners of the firm. The balance sheet of a typical firm is shown in Table 1. The assets of firms comprise fixed capital and inventories as well as certain cash balance and the financing of the firms’ activities happens via loans and via own funds. Table 1 shows furthermore that each firm and bank is owned by households. Thus, the entire net worth of the economy lies with the households.

When agents interact money is constantly transferred from one resting place to another. All these activities are monitored by a transaction matrix. Table 2 shows a consolidated version of this matrix where minus signs indicate money outflows while plus signs indicate that money is received. One can see, for example, that all consumption expenditure constitutes an expense for the households while it is a revenue for firms. Wages, in contrast, are paid by firms and received by households. The money in the economy is thus
in a permanent circular flow. Correspondingly, as illustrated by Figure 3, on the real side of the economy consumption goods are constantly transferred from businesses to households while labor services flow in the other direction. Moreover, businesses trade goods among each other. The two planes in Figure 3 represent the two streams which are part of every market transaction and this illustrates that the real sphere and the monetary sphere are strictly separated in the model.

2.3 Bankruptcy

If a firm is unable to serve its debt then it has to declare illiquidity. In such a situation all banks concede to the firms to defer their payments by one time period. The redemption of debt, however, is only effected to the extent that the necessary interest payments have been made. A firm which has declared illiquidity cannot get new credit from any bank. If in the next period the firm can meet its obligations then it regains its good creditor status and can continue its operations. Otherwise, it has to file bankruptcy. In the case of bankruptcy the firm is given one more time period to sell of its remaining assets and is subsequently withdrawn from the market. All physical assets which cannot or have not be sold at this point are lost. Finally, the bankrupt’s money assets are evenly distributed among its creditors where debentures take prevalence over equity. For each firm that goes bankrupt a new firm is created. The creation of a new firm is financed by households who make equity investments. When the firm is created it settles at a randomly chosen node. When a firm is created it knows the median price in its target markets as well as the median wage in the economy.

In the case of the illiquidity of a bank the bank stops its operations entirely. That is, it does not take on new time deposits nor does it issue new loans. It rather waits until all loans have been paid back or written off. Any incoming liquidity is immediately distributed to the savers according to a scheme
which respects the relative quantities of the claims. When there are no more outstanding loans and the bank’s equity is positive it resumes its operations. Otherwise it goes bankrupt and will be replaced by a new bank.

2.4 Time periods

The model operates sequentially with each time period representing one month. Each time \( t \) period consists of a multitude of time points at which the various actions take place. No two actions in this model ever happen at once so that the number of time steps within one month corresponds to the number of performed actions. All these points in time which lie somewhere within a time period are labeled as \( t^* \). These actions are grouped into certain categories which are carried out successively.

At the beginning of a time period starts each firm adds the products of the last time period to its inventories and offers these goods on its target markets. Subsequently, the households calculate their reservation wage and offer their manpower in the labor market. Moreover, the banks offer funds in the market for loans and the investment bank offers shares in the equity market. When all these offers are ready the firms start their investment activities. In a random order they consult the providers of their input factors and make the investments if they are deemed profitable. This also involves the issuance of credit. When all investment possibilities are exhausted, either because the desired goods are sold out or because there is no more demand, the firms pay their workers and the banks adjust their interest rate policy. After that, the households allocate their budget by purchasing consumer goods, equity shares, and savings contracts. When all these transactions are completed the firms consult their inventories and set their sales price for the next time period. The banks then determine their lending target for the next time period. Thereafter, the banks and the firms pay their credit obligations, prepare their financial statements, and pay out dividends. If a firm or bank
cannot meet its contractual obligation it goes bankrupt. At the end of a time period the remaining firms then resume production (see Figure 4).

2.5 Implementation

The model is implemented on a Java-based platform which is called JAMEL (Java Agent-based MacroEconomic Laboratory, see Seppecher, 2011). Java is an object-oriented programming language. Thus, every entity that appears in the model, be it an agent, a bank account, or a market, is an object of a certain class. Even the time line is an object. All objects in the model can be categorized as carrier objects, circulating objects, and enabling objects. Carrier objects are actual agents, like households and firms, who can interact economically. They do this by transferring circulating objects between them. All other objects are then enabling objects and are used to classify and define the relationships between agents. Moreover, some of these objects are used to monitor the relationships between agents either on behalf of an agent or on behalf of the modeler. In general, this object-oriented setup is well suited to build circular flow models because the accounting framework is implied by the transactions of the agents. Moreover, object-oriented programming allows to build and analyze relatively complex models in relatively parsimonious fashion.

Figure 5 shows how the output of such a model looks. It is an economic observatory which fully monitors every market and visualizes the results in real time. The analyst may thus follow the developments of certain aggregates and the distribution behind them (top row) or the disaggregate populations which constitute the markets (bottom rows). Over all, it can thus be analyzed how the system reacts to shocks and how economic developments are reflected in the system of accounts.
3 Household behavior

3.1 Purchases and money demand

Every action that a household performs concerns the acquisition of a good. Not only consumer goods, but also money, equity shares, and receivable amounts of money are considered as goods. The receivable amounts are further categorized according to the time horizon by which the money is to be received. It is assumed that all goods of a certain type are of the same quality. Hence, the only feature which allows households to distinguish between goods of a kind is their price. All goods are purchased in single units and are valued according to the law of diminishing marginal utility. Thus, as the quantity of a good that a household possesses increases, his valuation of an additional unit of the good decreases. All households fully consume their consumption goods at the end of each time period. At the beginning of a time period the quantity of consumption goods in the possession of the households is thus zero.

The preferences of the households are represented by sequences of intended actions. These sequences describe the order and the proportions in which the different goods are desired. The sequences are given exogenously and express the households’ deliberate wants. Only the goods that appear in the sequence of a household are considered for purchase, one after the other. In the sequences all goods are listed in their smallest possible units. It is permissible to say that the first element of a sequence displays a household’s most urgent desire because this good is preferred to all other goods in the first moment of a time period. After that, however, when the first action is completed, the second element of the sequence represents his greatest desire. Nothing can be said about how these goods are valued relative to each other. It is furthermore absolutely not necessary that the marginal utility that the household associates with the acquisition of the first good is greater than
the marginal utility derived from the second good.\footnote{Rather, these marginal utilities are incomparable (see Section 7.1).} Since all goods are, in general, to a certain extent substitutes and complements to each other, it is possible that the purchase of a good, or the non-purchase for that matter, changes the situation and the planning of a household entirely. Or else it is possible that in the time between two purchases a household receives a piece of information which alters his desires. Therefore, the second desired good cannot be considered the “second most preferred good” of the first action. The sequences of intended actions are hence not transitive.

The sequences of intended actions are in principle infinitely long. That is, no household exhibits a saturation of wants. This assumption, while being at odds with the first proposition of Gossen (1854, p.4), does not conflict with diminishing marginal utility (Mises, 2008, p.124). Yet, the fact that the households purchase single units of different good in an order that is determined by their preferences implies that the second proposition of Gossen (1854, p.12) is respected in this model because this mode of operation implies that the households try to balance their consumption to the greatest possible extent. However, as Rothbard (2009, pp.302) makes clear, this does not mean that the marginal utilities that are derived from the last purchased units of all goods are equal to one another, nor are they equal to the marginal utility of their purchasing price. Rather, in each purchasing decision the households weigh the utility of the considered good against the utility of money. A household will engage in a transaction if the marginal utility that he derives from adding the good to his ownership exceeds the marginal utility that he attaches to the money that he would have to give up in exchange.

It follows from the above that in every purchasing decision each household does have a reservation price. This is the maximum price at which he is willing and able to buy the desired good. With every unit of a good that a household purchases the marginal utility that would be derived from an
additional unit of the good decreases while at the same time the marginal utility of money increases. Hence, as the acquired quantity of a given type of good increases the corresponding reservation price falls (see Rothbard, 2009, pp.238, p.281). At a given point in time \( t^* \) the reservation price for a given type of good \( x \) is thus modeled as a function of the household’s current money budget and the number of units of the good that the household already possesses,

\[
p_{x}^{\text{res}}(t^*) = M^h(t^*) - g_{x,t}(\text{units of } x \text{ owned}),
\]

with \( g : \mathbb{N} \rightarrow \mathbb{R} \) monotonically increasing. The monotonicity of \( g_{x,t}(\cdot) \) integrates both effects that the purchase of a good has on the household’s willingness to pay: the decreased valuation of the next unit of the good and the increased valuation of money. The subscript \( t \) indicates that this relative valuation need not be constant over different time periods. Moreover, the subscript \( x \) documents that the extent to which a purchase affects the reservation price may be different for each type of good.\(^5\)

One should note that the function \( g(\cdot) \) is independent of the actual money holdings of a household. This reflects the fact that money is not held irrespective of its purchasing power. People hold money only because they want to buy things in the future and because they are uncertain about their purchases (Rothbard, 2009, pp.265). Consequently, the more goods a monetary unit can buy the less money are the households, \textit{ceteris paribus}, inclined to hold (Rothbard, 2009, pp.759). Equation (4) embodies this principle because if the prices of goods fall then the reservation prices are less likely to be binding. Consequently, if the purchasing power of money increases the money demand of the households declines and the demanded quantity increases. And this is independent of the motives that make the households wish to hold money.

\(^5\)The assumption of a functional relationship is arbitrary. As long as the monotonicity requirement is not violated one could abandon functionality all together.
For each household, the sequence of intended actions is constructed as a concatenation of elements which are randomly drawn from a given preference set. For example, if the preference set of a household is

\[
\{B, B, C, 100 \text{ gr. (5 months)}, D\}
\]

then his sequence of intended actions may look like the one shown in Table 3. The more frequent an element occurs in the preference set the more often it occurs in the sequence and, moreover, the more frequent an element the flatter is the corresponding function \(g_{x,t}(\cdot)\). That is, each household knows the relative importance that the goods have for him and takes this into account when forming his reservation prices. The elasticities of substitution between goods and the cross elasticity of demand are therefore implied in the preferences and the reservation prices of the households.

When executing demand the household “consults” his sequence of intended actions and for each element searches the relevant market. It is assumed that the household solicits three offers for each good that he considers purchasing. If the price of the cheapest offer found is below his reservation price he makes the purchase and considers the next element of the sequence. If a desired good is unavailable or too expensive with respect to his reservation price the household rejects the offer and proceeds with the next preferred good. Moreover, from this point on he will skip all elements of the sequence which express a preference for this type of good. This way, the household works through his preferences and makes the desired purchases until he has declined an offer for all elements that appear in his preference set.

Table 3 illustrates how the allocation algorithm of households works. In this example a household whose preferences are given by equation (5) is endowed with a budget of 1000 grs. The household’s first action concerns the purchase of a good of type B. The lowest price that he finds in the market is 90 grs. Since this amount is within his budget he buys one unit of good B and subsequently again considers offers for good B with now 910 grs. in hand.
<table>
<thead>
<tr>
<th>Budget</th>
<th>Preference</th>
<th>Res. Price</th>
<th>Prices</th>
<th>Purchase</th>
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<tr>
<td>1000</td>
<td>1st B</td>
<td>1000</td>
<td>{92,90,95}</td>
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</tr>
<tr>
<td>910</td>
<td>2nd B</td>
<td>900</td>
<td>{95,97,98}</td>
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</tr>
<tr>
<td>815</td>
<td>1st C</td>
<td>815</td>
<td>{52,50,45}</td>
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<tr>
<td>770</td>
<td>100th gr. (5m)</td>
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<tr>
<td>673</td>
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<tr>
<td>622</td>
<td>3rd B</td>
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</tbody>
</table>

Table 3: An example of the allocation algorithm of households. The sequence of intended actions lists the goods that the household desires in the course of time (second column). The reservation price describes his willingness and ability to buy the good (third column). For each preferred good the household consults three offers and chooses the one with the lowest price (fourth column). A purchase is made if the price of the best offer is below the reservation price. Once this is not the case the consumer stops searching for this type of good.
His reservation demand for money has now increased since he has already purchased one unit of good B. Hence, his reservation price is now 900 grs, but the best offer is still within his budget and thus he makes the purchase. This procedure continues until the 6th unit of good B when for the first time the maximum buying price is below the offered price. The consumer thus declines the offer and regards his demand for good B as satisfied. With the remaining budget he buys another unit of good C and D and then cancels his operations. He will then have bought five units of good B and three units of good C and D, respectively. Moreover, he will have transferred 200 grs. from his checking account to his savings accounts at the banks whose offers were chosen. His cash balance at the end of the time period will be 16 grs.

Having completed all purchasing activities each households forms an estimate of the purchasing power of money by dividing the number of purchased goods by the budget that he had at the beginning of the time period:

\[
PPM^* = \frac{\text{Number of purchases}}{\text{budget}_{t^*=0}}
\]  

(6)

This estimate is used as a proxy variable in order to assess the real value of his prospective wage income (see Section 3.3). This approach follows the regression theorem of Ludwig von Mises (2008, pp.405) which explains that a man can only establish a judgment about the future purchasing power of money by looking at its purchasing power in the immediate past.

### 3.2 Saving

The sequences of intended actions not only include different kinds of consumption goods but also investment possibilities. One investment strategy is to lend money to banks via savings contracts. In these contracts the banks offer to pay out a certain amount of money at some point in the future. The households have preferences regarding the durations of their time deposits and choose the contracts accordingly. They may, for instance, desire
a receivable amount of 100 grains in five months time. The interest rates of such contracts, however, are set by the banks. Together, the duration and the interest rate of a contract imply a discount at which the households can buy future money. The second investment strategy of the households is to invest money in entrepreneurial ventures. In buying shares of a company a household acquires ownership over parts of a company and is thus entitled to future dividend payments. For all these investment possibilities neither the risk nor the expected return are quantifiable. The households act in an environment of uncertainty and any investment is therefore speculative. Yet, these investments are in principle not more or less speculative than any other action of the households. A man does not know beforehand whether a desired good really serves his needs, but he assumes so and thus acts (Mises, 2008, pp.105).

The desire to purchase future money or to invest in new firms is an expression of the time preference of the households. Time preference is thus here understood as supply schedule of saved present money. This supply is ultimately only determined by the preferences of the households because the interest rates and the issuing price of stocks are endogenous to the model. In fact, it is precisely the supply of saved funds which indirectly determines the rates of interest and the prices of stock (see Section 5). The connection between time preference and the rate of interest is thus fully intact in this model (cf. Reisman, 1998). One should note, furthermore, that for all households the ratio between consumption and savings is independent of the household’s demand for present money, as postulated by Rothbard (2009, p.774).

### 3.3 Pre-income preferences

The households also have preferences regarding their wealth position. In principle, there are two ways for a household to steer his budgetary situation. He may withdraw funds from a company that he owns or he may engage in
paid labor. Other sources of income are beyond the control of a household. There is no stock market on which he could sell his property and interest revenue only constitutes a fixed income stream.

A household’s willingness to work is the result of a trade-off between his capability to buy goods and his capability to enjoy leisure time. Leisure time is a type of consumer good. The households gain leisure time by abstaining from work, but such abstention is always associated with a certain wage income foregone. As in any other exchange, an individual will thus choose to work if the marginal utility derived from the wage income exceeds the marginal utility of the leisure time that has to be given up when working (cf. Rothbard, 2009, p.218).

Because of the law of diminishing marginal utility the households value more leisure time higher than less, but the marginal utility of leisure decreases as the number of work-free time periods increases. At the same time, the higher the cash hodlings of a household the lower is the marginal utility that he derives from an additional wage income. Each household therefore has a reservation wage which depends on his past work record and on his expected real consumption.

Labor in this model is traded in units of one month. Thus, the smallest possible unit by which leisure time can be accumulated is one month too. By assumption the households make the number of consecutive months of unemployment the basis of their decision. With each month that a worker remains unemployed he accumulates an additional unit of leisure time and, ceteris paribus, his reservation wage falls. As soon as he accepts a job his accumulated stock of leisure time drops to zero and his reservation wage raises again. Furthermore, the households calculate their expected real consumption by multiplying their current budget with their estimate of the purchasing power of money $PPM^*$. The higher this number, the higher his reservation wage will be. Denoting the accumulated stock of leisure time as $L$ and the
prospective real consumption as \( c \) one may write the reservation wage function as

\[
w_t^{res}(L, c) : \mathbb{N}^2 \mapsto \mathbb{N} \quad \text{with} \quad \frac{\Delta w_t^{res}}{\Delta L} < 0 \quad \text{and} \quad \frac{\Delta w_t^{res}}{\Delta c} > 0 . \tag{7}
\]

As long as the monotonicity requirements are fulfilled the functional form of \( w_t^{res}(\cdot) \) can be arbitrarily chosen because this function only reflects the preferences that a household has concerning his decision to work. It is thus the description of a purely subjective statement which may change over time. All unemployed households are always available in the labor market. If a household receives a job offer with a wage that is greater than his reservation wage he will accept the offer and otherwise he will reject it.

Depending on how a population values leisure relative to other goods it may be the case that an increase in nominal wages leads to a reduction in the labor supply. The households then use some of their additional income to “buy” leisure time. Such an economy exhibits a backward bending supply curve of labor (cf. Rothbard, 2009, pp.572). While abstracting from hourly wages the model describes this via the fact that the nominal non-labor income of an economy falls as the wage level increases.

The second option for households to increase their budget is to withdraw liquid capital from the firms they own. The dividend obligations that the households impose upon firms are however not modeled explicitly here. In every time period each firm pays out a certain proportion of its free cash to its shareholders. This proportion \( \phi_t \) is randomly drawn from a uniform distribution over the interval \([0,1]\). The randomness of this parameter represents the fact that this decision is not only guided by one household’s desire to enhance his budget, but also by management considerations and by negotiations with other shareholders (see Section 4.1).
4 Firm behavior

The objective of firms is to maximize profits while avoiding illiquidity. Unlike the households the firms therefore do not act according to a preference set but strive to position themselves optimally within a system of economic constraints. The physical constraints that a firm has to respect are given by its production function. This function prescribes that output depends mechanically on investment and that only capital investments can increase a firm’s productivity (Section 2.1). The balance sheet and the accounting rules, on the other hand, represent the financial constraints of a firm. In particular, these constraints are given by the liquidity position of a firm and the relation between profit and interest obligations. Finally, the economic constraints that a firm faces are the prices and the demand that it finds in the markets.

4.1 Liquidity management

Every firm, when it is created, is equipped with the money that has been provided by its equity investors. The firms use this money for investment purposes and subsequently sell their products. All revenues that a firm generates are either reinvested or they are eventually paid out to the creditors of the firm. The compensations paid to the creditors are either interest and redemption payments, which are always prioritized, or they are dividend payments. The firms therefore allocate their funds according to a scheme which is illustrated in Table 4. In every time period, when all transactions except dividend payments are completed, each firm builds a reserve in order to pay the credit obligations of the next time period. If the firm’s cash holdings are thereby exhausted then the dividend payments and the firm’s internal investment budget will both be zero. Otherwise, the firm pays the fraction $\phi_t$ of the remaining funds to its shareholders and allocates the rest for reinvestment.
If $M^I_{t^*} \leq inst_{t+1}$ | Else
---|---
$Res_t = M^I_{t^*}$ | $Res_t = inst_{t+1}$
$Div_t = 0$ | $Div_t = \phi_t \cdot (M^I_{t^*} - Res_t)$
$Inv_t = 0$ | $Inv_t = (1 - \phi_t) \cdot (M^I_{t^*} - Res_t)$

Table 4: The liquidity management of firms. $M^I_{t^*}$ denotes the cash holdings of a firm having paid its credit obligations in time period $t$, $inst_{t+1}$ are the credit obligations of the next time period, $Res_t$ are reserves, $Div_t$ are dividend payments, $Inv_t$ are funds which are made available for reinvestment, and $\phi_t$ represents the fraction of liquid funds which is withdrawn by the shareholders (see Section 3.3).

4.2 Sales and investment

In every time period, all goods that are in the possession of a firm are offered for sale. The offered goods thus comprise the remaining inventories and the produce of the last time period $y_{t-1}$. The offered goods $o_t$ minus the sold goods $s_t$ of a given time period then determine the new stock of remaining inventories $in_t$, i.e.

$$o_t = y_{t-1} + in_{t-1}$$
$$in_t = o_t - s_t$$

All goods that are offered in a given time period are offered at the same price. That is, the firms do not discriminate between buyers.

The sales strategy of a firm consists in the choice of the price and the number of products that it offers in the market. The sole objective of such a strategy is to maximize revenue because all investment expenditures are sunk costs at the point where firms make their offers. The respective combination of price and quantity which would maximize revenue is however always unknown to
the firms. Firms do not know the extent to which their customers are willing to accommodate a certain price nor do they know the sales strategies of their competitors. Thus, both the pricing and the investment decision of a firm are speculative actions.

In order to find an estimate of the optimal price-quantity combination the firms apply a process of try and error. In particular, each firm always aims to find a price-quantity combination where a certain percentage of the offered goods is withheld from the market. For only if there remains an unsold quantity can the firm know that it does not sell its goods below the market value. Conversely, if the inventories of a firm keep piling up this indicates to the firm that its proposed price or its level of investment are too high. Each firm therefore has a target range of remaining inventories that is proportional to the quantity of goods on offer. Whenever sales are too low and the remaining inventories are outside the targeted range the firms either cut the price or the target level of production.\(^6\) Conversely, a firm that sells all offered goods will raise either the price or the target level of production. Which of the changes a firm makes is decided at random.\(^7\) If the level of inventories lies within the desired range the firm will not change its strategy. The reaction function of firms can thus be written as

\[
\begin{align*}
  p_{t+1} &= p_t \cdot (1 - \alpha) \quad \text{or} \quad y^*_t = y^*_t \cdot (1 - \alpha) \quad \text{if} \quad i_n_t > (1 - \sigma) \cdot o_t \\
  p_{t+1} &= p_t \quad \text{and} \quad y^*_{t+1} = y^*_t \quad \text{if} \quad 0 < i_n_t \leq (1 - \sigma) \cdot o_t \\
  p_{t+1} &= p_t \cdot (1 + \alpha) \quad \text{or} \quad y^*_{t+1} = y^*_t \cdot (1 + \alpha) \quad \text{if} \quad i_n_t = 0,
\end{align*}
\]

where \(y^*\) is the targeted level of production and \(\alpha \in (0, 1)\) and \(\sigma \in (0, 1)\) are behavioral parameters that respectively describe the strategic flexibility and

\(^6\)The firms can only adjust the target and not the production itself because they do not know whether the necessary supplies will be available.

\(^7\)One might consider this decision as a “preference” of the entrepreneur which reflects his deliberate will.
the targeted sales ratio of firms.\textsuperscript{8}

The pricing rationale of equation (8) motivates the sellers to withhold a certain quantity from the market. This reservation demand is however not identical with the Rothbardian (2009, pp.137) demand to hold. It is not only a profitability consideration which constitutes this demand, but also a knowledge problem. A side effect of these inventories is that they cushion demand fluctuations, but mainly it is the uncertainty about the optimal strategy which induces the firms to keep inventories.

When a firm sells a good it makes a revenue and at the same time incurs a cost equal to the book value of the good. The firms are economically obliged to sell their goods since this is their only source of revenue. Hence, if necessary the firms will sell unprofitably instead of making no revenue at all. The firms’ only way to control their profitability lies in their investment decision. When choosing investments any given firm uses its own current sales price as a benchmark and compares this price with the unit costs of the different investment possibilities. If the sales price exceeds the marginal unit costs of a given investment $u c$ then the firm expects to earn money over the investment cycle and approves the investment, i.e.

$$\text{invest if } u c < p_t - \rho .$$

(9)

Here $\rho$ is a behavioral parameter which guards the firm against losses. This parameter not only reflects the desired markup of the entrepreneur, but also the firm’s uncertainty about the elasticity of demand and potential price changes.

In order to calculate the unit costs of a particular investment the firms need to know the required investment expenditure and the increment in output that the considered input factor generates. The required expenditure is either the proposed price of the considered good or the wage that the firm offers in the

\textsuperscript{8}The parameter $\alpha$ has an additional stochastic component.
labor market. Potentially, the firms also need to take the rate of interest into account. The increment in output is furthermore given by the difference of the value of the production function between the considered and the current level of investment $\Delta f(l, x, k)$.

In order to make investments comparable which last over different time horizons the firms always consider the *average* unit costs per time period. In the case of fixed-capital these average costs are given by the monthly depreciation costs of the investment.\(^9\) Financing costs, in turn, are taken into account by the average of the interest payments that occur over the duration of the loan. Thus, denoting investment expenditure as $i$ and the life span of an investment as $T_i$ and further denoting required credit volume as $D$ and loan duration as $T_d$, then the average unit costs of an investment can be written as

$$uc = \frac{e/T + \sum_{t=1}^{T_d} int_t(D)/T_d}{\Delta f(l, x, k)}.$$  

The decision process that a firm undergoes in each investment decision thus starts by searching the markets of all input factors. In each relevant goods market the firm consults a number of offers and chooses the one with the lowest price. In addition, the firm selects an offer from the labor market and determines the wage that it offers to that worker. This decision is based on the firm’s past hiring experience. If in the previous hiring attempt the job applicant refused the job offer then the firm now offers a higher wage and it reduces the offered wage if the last applicant accepted the offer, i.e.

$$w_{t^*} = w_{t^*} \cdot (1 - \beta) \quad \text{if accepted}$$

$$w_{t^*} = w_{t^*} \cdot (1 + \beta) \quad \text{if refused.}$$

Conditional on the availability of the factors and their prices the firm then calculates the unit costs of each type of investment and selects the one with

---

\(^9\)The marginal output of a fixed-capital good is the additional output that it yields in the next time period.
the lowest unit costs. Subsequently, the firm applies equation (9) and test whether its new level of production remains below $y^*$. If both conditions are fulfilled then the firm transfers money to the seller or worker, updates its current level of production, and then considers the next investment.

As long as a firm can fund its investments internally it will not look for credit. At some point, however, the internal budget of the firm will be exhausted and the firm then needs to consult the credit market before turning to the factor markets. If credit is available and the unit costs of the preferred investment inclusive of financing costs signalize profitability then the firm signs a credit contract, receives money from the bank, and makes the purchase. Credit is only taken up when it is needed and firms spend these acquired funds immediately. Similarly, the supply of capital goods is “just in time”. That is, purchased capital goods are never stored, but immediately put to use.
5 Bank behavior

The banks in the model, just like the firms, operate under the profit motive. In the pursuit of profit the banks serve as the financial intermediaries between households and firms. There are two types of banks, commercial banks who convert time deposits into loans and investment banks who facilitate the equity investments of the households. Moreover, commercial banks offer payment services to their customers which they do free of charge.

5.1 Commercial Banks

5.1.1 Liquidity management

The liquidity management of commercial banks distinguishes between three categories of funds which are used for separate purposes. The sight deposits of a bank are only used for the ongoing payments of the depositors and are left aside in all other activities. Secondly, the pool of loanable funds, which is constituted by the time deposits of a bank, is used to make loans or to redeem time deposits. Finally, the own funds of a bank are either used as a cash reserve or to pay interest and dividends. The banks do not engage in proprietary banking, i.e. the banks do not lend out their own funds (Figure 6).

In order to maintain this separation of funds the commercial banks decompose their cash flow into a redemption component and a return component. The interest payments that a bank receives represent free cash flow and are added to the bank’s own funds while the received redemption payments are redirected to the pool of loanable funds. If a bank is unable to reclaim all its loans then the own funds of a bank are used to replenish the pool of loanable funds. This way the bank makes sure that its dividend payments never exceed its equity. The key figure for the commercial banking activities of a
bank is its lending capacity \( LC \). This capacity corresponds to the sum of loanable funds and outstanding loans.

### 5.1.2 Commercial banking

In analogy with the firms, the behavior of banks is determined by a revenue-maximizing sales strategy and a profit-maximizing investment strategy. Yet, the profit maximization rationale of banks differs from the one of firms in that banks base their decision on the relation between total revenue and total costs whereas firms analyze their investments on a marginal basis. This difference is a consequence of the fact that firms choose the quantity they purchase upon given input prices while banks, in contrast, set the interest rate for savings and then passively accept the time deposits of households. The saving decisions of the households thus determine the lending capacity and the cost structure of each bank and each bank takes these variables as given in its decision processes.

Just as firms the banks operate under uncertainty. The banks cannot know the optimal prices at which they trade future moneys nor can they know the strategies of their competitors. The rationality of banks is thus to engage in quantity targeting. With a given interest rate for savings a bank attracts, \( ceteris\ paribus \), the same amount of savings in each time period. The bank thus accumulates a pool of loanable funds which, \( ceteris\ paribus \), eventually reaches a constant level. At this level the redemption payments to households equal the new time deposits received. The bank will be inclined to use a large portion of these funds in its lending operations because the issuance of credit is its source of revenue while the time deposits are associated with interest costs. Yet, it is not advantageous for the bank to lend out all loanable funds at once. The revenue-maximizing state of a bank is rather a situation in which the amount of newly issued loans is constant over time and equal to the redemption payments received. In such a state, a bank apportions the
issuance of credit evenly over time and thus intertemporally withholds as much quantity from the market as possible.

Furthermore, each bank has a certain reservation demand for its loanable funds which is described by a behavioral parameter $\delta \in (0, 1)$. The banks keep a certain amount of time deposits to themselves first of all in order to cushion fluctuations in the stock of time deposits. In addition, the conscious withholding of funds is also the only way for a bank to find out whether it offers credit below market value (in analogy with Section 4.2). At each moment in time the banks act as if their current lending capacity was in a steady state. The strategy of banks is thus to transform a conceived steady state level of savings into a steady state of receivables on the asset side. The targeted lending volume of a bank is thus the volume which, if constantly applied, leads to the state in which the loanable funds in hand equal the bank’s reservation demand while the net outflow of loans is zero. Conditional upon the average duration of loans $\langle T \rangle$ this volume can be written as

$$D_{t+1}^* = \delta \frac{L C_t}{\sum_{\tau=0}^{\langle T \rangle} \langle T \rangle - \tau}.$$

The summand in the denominator describes the net outflow of loanable funds which diminishes the closer the bank gets to the steady state. According to this formula a steady state would be reached after $\langle T \rangle$ time periods.

The pricing strategy of banks with regard to the interest rate for loans is thus to lower the rate whenever new loans are below the targeted volume and to raise the rate if the quantity of new loans lies above the threshold, i.e.

$$r_{d,t+1} = r_{d,t} \cdot (1 - \gamma) \quad \text{if} \quad D_t < D_t^*$$

$$r_{d,t+1} = r_{d,t} \cdot (1 + \gamma) \quad \text{if} \quad D_t > D_t^*$$

The extent to which the banks adapt their lending rates is described by a behavioral parameter $\gamma \in (0, 1)$. 

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The variable $r_d$ represents the base lending rate of a bank. In order to discriminate between borrowers the banks charge a risk premium on top of this rate. When applying for a loan each firm has to reveal its equity ratio to the bank and the banks calculate the final interest rate as

$$r_d^f = r_d + \frac{r_d}{\chi},$$

where $\chi$ is the interest coverage ratio of the applying firm. This ratio is defined as the firm’s last period’s net profit divided by the interest payments it has to fulfil in the next time period.

When all lending operations of a time period are completed each bank has a new revenue structure. Moreover, each bank has a cost structure which is determined by its stock of time deposits. Each bank then evaluates whether the last change in the interest rate for savings has improved its profitability. Profitability is measured as the relation between total average revenue per time period $TAR$ and total average costs $TAC$. For a bank with a portfolio of $N$ loans and $N$ savings contracts these figures can be calculated as

$$TAR_t = \sum_{n=1}^{N} \sum_{t=1}^{T} int_t(D_{0,n})/T_n$$

$$TAC_t = \sum_{n=1}^{N} S_n \left((1 + r_n)^{T_n} - 1\right) / T_n.$$ 

If the bank’s profitability $\pi = TAR/TAC$ has increased in the last time period then the bank takes this as an indication to further its investment strategy and moves the interest rate for savings in the same direction as it did in the last time period. If, in contrast, the profitability has decreased the bank revises its investment strategy and moves $r_s$ in the other direction. With $\psi \in (0, 1)$ as the behavioral parameter which describes the interest rate flexibility for savings this means
This pricing rule again embodies the subjectivity theory of value. The price of loans is ultimately determined by the firms’ willingness to pay. If the demand for loans is high then the lending rate will follow. Conversely, the lending rate will fall if the offered credit does not meet sufficient demand. The banks are economically obliged to make loans since the issuance of credit is their only source of revenue. If necessary the banks even lend money unprofitably instead of making no revenue at all.

Finally, when the credit transactions of a time period are completed each bank reserves the amount of money that is necessary to make the interest payments in the next two time periods. If its own funds are thereby exhausted then its dividend payments are zero. Otherwise, the firm pays the fraction $\phi_t$ of the remaining funds to its shareholders and keeps the rest as a reserve. Denoting the cash holdings after interest payments as $M_{t^*}$ one may summarize the decision to pay dividends as

$$
\text{div}_t = \phi_t \cdot (M_{t^*} - \text{int}_{t+1}) \quad \text{if} \quad M_{t^*} > \text{int}_{t+1}
$$

$$
\text{div}_t = 0 \quad \text{if} \quad M_{t^*} \leq \text{int}_{t+1}.
$$
5.2 Investment banking

There is only one investment bank in this model which manages all equity investments. Since the number of firms in the economy is constant a new public offering can only occur after a bankruptcy. In the case of bankruptcy the shares of the bankrupt firm are transferred to the investment bank which subsequently offer these shares to the households. The pricing of the shares works analogously to the pricing of other goods. In order to maximize revenue the investment bank tries to set the price to a level where a certain quantity is withheld from the market. Denoting the number of offered shares as \( o_t^{eq} \) and the number of unsold shares as \( in_t^{eq} \) the pricing decision can be written as follows.

\[
\begin{align*}
    p_{t+1}^{eq} &= p_t^{eq} \cdot (1 + \xi) \quad \text{if} \quad in_t^{eq} < \nu o_t^{eq} \\
    p_{t+1}^{eq} &= p_t^{eq} \cdot (1 - \xi) \quad \text{if} \quad in_t^{eq} > \nu o_t^{eq}
\end{align*}
\]

Here, \( \xi \in (0, 1) \) and \( \nu \in (0, 1) \) are again behavioral parameters. The money that the bank raises when equity shares are sold is then transferred to the accounts of the start-up firms. In each sale the bank keeps a certain percentage of the transaction volume to itself. This commission is determined by the parameter \( \omega \in (0, 1) \).
6 The functioning of the model

6.1 Supply and demand

A market in this model is constituted by a list of offers. In each offer, the offerer specifies the quantity and the price of the product that is offered for sale. For every market the total quantity supplied is thus determined by the sum of the individual quantities. Formally, such a market can be described with the help of a diagram which measures offered quantity on the abscissa and unit prices on the ordinate. In such a diagram every offer constitutes a horizontal supply-curve of a given length. By sorting these offers in ascending price order while cumulating over their quantity it is possible to construct an upward sloping supply curve (Figure 7). In contrast to its Marshallian counterpart, however, such a curve does not describe the hypothetical total supply given a hypothetical equilibrium price, but rather the price spectrum at which the marketable quantity is available.

Transactions occur when the agents on the demand side of a market respond to the offers. Each potential customer first consults a number of offers and then chooses the one with the lowest price. The selection probability of an offer is proportional to the quantity that it contains. Every market looks different to every potential buyer who enters it because only the offers that a customer finds when searching the market are relevant offers to him. On an individual basis a market can thus be depicted by combining the relevant individual supply curves with the buyer’s demand curve, which, in turn, is a vertical line that is bounded from above by a horizontal element which describes the buyer’s reservation price. Moreover, since all purchasing decisions concern single units the vertical part of the curve is located at one unit on the abscissa (Figure 8). A transaction occurs if at least one supply curve lies on or below the horizontal part of the demand curve. In this case a purchase is rational for the buyer. In Misesian (2008, pp.245) terms one
can say that after every transaction the system reaches a plain state of rest because trading comes to a halt. Subsequently, the seller will update his offer taking into account that the sold quantity is no longer available. His supply curve thus becomes shorter and a new state of the market comes into being.

Due to the knowledge constraints of the market participants no market in this model works without friction. There is no mechanism which matches the higher priced offers to the buyers with high reservation prices. Rather, each buyer deals with the market situation from his own perspective and acts to his own greatest advantage. Since the results of a market search are established stochastically the exact market results are stochastic too. Moreover, the timing of a market activity matters for the result since every market transaction changes the market conditions for other market participants. Yet, the fact that the agents enter the market in a random order guarantees that no agent has a systematic advantage over others. At the end of a time period each offerer will be left with a certain sales ratio. The market has cleared if all goods were sold but in most cases there will remain an unsold quantity in stock. There are also extreme cases in which there is either no demand for an offered good or no supply of a good that is desired by the customers. In these cases no transactions occur.

The described concept of a market is by far less abstract than its neoclassical counterpart. Here, a market is not an independent entity which miraculously brings about a certain state of affairs. It is rather an encompassing of certain related activities all of which are subject to the principles of human action. Only where agents act do markets come into existence. And only mutual agreement leads to a transaction. In order to reach such agreement there must be some sort of communication between the seller and the buyer where they exchange signals about their preferences. Such communication is a form of action and it is therefore speculative and time-bound. It is here modeled by the setting of prices on the one end and by the consulting of offers on the other end. This simplified version of a negotiation process then may or may
not lead to a deal. Finally, if a transaction occurs, it is a two-sided affair in which money and a good change hands.\textsuperscript{10}

There are two markets in this model which depart from the formalizations of the Figures 7 and 8. The market for future money, i.e. the savings market, escapes this formalization since in this case the individual supply curves are infinitely long. Moreover, the labor market differs from the other markets because in this case the sellers are not the price setters. The labor supply curve rather describes a spectrum of reservation prices. The functioning of these markets is nonetheless analogous. In the case of the labor market the firms make offers to only one household at a time and this household will accept the job offer if the offered wage is above his reservation wage or else he will decline the offer.

6.2 Steady states and competition

The market results that occur in each time period have a signaling function for the market participants. Some of the offerers who have sold all their goods will raise their asked price while those who have not sold a sufficient quantity will tend to lower their price. Given that the customers prefer cheap offers to expensive offers the pricing rationale of the firms thus implies that market transactions have a stabilizing effect on the market in the sense that the different prices in the market tend to move towards each other. Market activities never lead to a divergence of prices, nor can they induce

\textsuperscript{10}While being in perfect agreement with praxeological principles this description of a market deviates from the main body of Austrian literature. Orthodox Austrians emphasize that market prices are determined, within a certain margin, by the preferences of the acting parties (Rothbard, 2009, pp.). The genesis of prices, however, is rarely brought up as an issue. The inclusion of speculative price setting into the concept of supply and demand, as it is done in this model, is an element which follows Wicksteed (1910, pp.) and, independent thereof, the post-Keynesian literature which makes contract formation a key principle of analysis, e.g. Godley and Lavoie (2007) and Davidson (2005).
the building up of price bubbles. Furthermore, after each time period some of the successful sellers will expand their operations while some of the less successful offerers will reduce their level of investment.

The state of a market is mainly determined by two factors: the degree of competition that prevails in the market and the supply conditions in the relevant factor markets. Consider first a market which is monopolized by a single firm. In a steady state this firm will be able to maintain its price-quantity combination over time because the same spending patterns reoccur in every time period. The firm’s inventories will therefore always remain within the desired range (cf. Equation (8)). Potentially, the firm will have chosen a price at which certain customers choose not to buy the product even if they could. The chosen strategy may or may not be profit-maximizing for the monopolists, but such is his decision. In such a state of the market the total quantity supplied and sold would be reduced vis-à-vis a strategy with a lower price level. If, however, the market served by two firms then each of them always has the possibility to secure a larger market share by undercutting the competitor. The competition between firms may drive down the prices to the level unit costs or it may lead to a cartel. A cartel would be characterized by a state in which all competing firms are able to keep their inventories in the desired range while Equation (9) never becomes binding. In any case, the higher the number of competitors the lower is the chance for a cartel formation. As a rule, the more firms there are in a market the lower the average price level and the higher the quantity that will be supplied.

If the degree of competition in a market is high then the prices in the factor markets may become binding. The investment rationale of firms is such that they exploit the possibilities to reduce unit costs whenever they occur. Therefore, the threshold of profitability is in general flexible and it may fall when more capital goods are available. However, whether or not the availability of physical capital offers a cost-reduction possibility depends on the prices of the capital goods. These, in turn, may be affected by the degree
of competition that prevails in the relevant supply chain. Prices, in general, reflect a the relative shortage of a good. If the demand for a certain good is high and there is only little supply then the prices of the good will be raised promptly. Conversely, the price will fall if the offered goods do not meet sufficient demand.

Under competitive conditions the interplay of supply and demand and the behavior of the agents thus works to the effect that the microeconomic structure is constantly changed. In every time period there will be different firms who are the marginal selling firms and accordingly the relative market shares of the firms vary. Yet, many of these changes will be mutually offsetting so that the macroeconomic state of the market is only affected to a lesser extent. Given constant preferences on the part of the households the economic system will eventually reach a state in which the total transaction volumes in all markets fluctuate around certain levels.\footnote{I am not sure at present whether this claim can be proven theoretically. The implementation of the model is not a proof of stability, but merely a numerical experiment.} The varying matching results that occur in the markets cannot alter the economic structure systematically and their effects are transient. If in a given time period the total demand in a particular market was lower than usual then the offerers will change their strategies accordingly, but if in the next time period demand goes up again then the strategy changes will immediately be revised. The macroeconomic variables of the economy will thus remain by and large at the same level. Such stationarity characterizes a macroeconomic steady state.

Such a steady state must not be confounded with a final state of rest as described by Mises (2008, pp.246), nor is this an equilibrium in the neoclassical sense. One can say that the agents speculate against a hypothetical equilibrium and the system therefore tends towards it, but such a state is never reached as new events occur which upset the convergence process. Such a steady state can also not be adequately described as a Misesian (2008, pp.251) stationary economy because there are winners and losers in every time period.
and the distribution of wealth changes constantly. Mises, however, postulates a constant wealth distribution.\textsuperscript{12}

### 6.3 Consumer sovereignty

Ultimately, the economic system in this model is ruled by the sum of the preference sets of the households. If the preference concerning a particular consumer good change then both the frequency with which the good is demanded and the corresponding reservation prices change. An increase in demand frequency corresponds to a decline of the reservation prices, and vice versa.

Let’s consider the case in which the demand for a certain consumer good falls. As a consequence, the revenue that is generated in this market falls and the affected firms will react to the piling up of inventories by lowering prices and output. Moreover, some firms, especially those with a relatively high financing costs, may have to file bankruptcy. Thus, a fall in demand for certain product triggers a fall in the demand for labor and capital, also because certain firms have to dismiss their workforce entirely. Therefore, such an event not only concerns the producers of the good in question, but also their suppliers and ultimately the entire line of production will be affected. At the same time, however, the releasing of resources offers new production possibilities for all other firms. Labor and the goods which are now less desired will become cheaper and these opportunities will be taken up by other firms who have the possibility to put these factors to a profitable use. Moreover, in deciding not to purchase a certain product the households also decide where to put the money alternatively. If the reduced demand happened at the favor of a different good then this will enhance the revenue of the producers of that

\textsuperscript{12}The question is whether Mises’ description of a stationary economy is actually consistent as he postulates both a constant wealth distribution and offsetting profit and loss.
good. This, in turn, will entail a different spending pattern on their part and thus affect the demand structure further. A permanent change in demand for a certain product therefore has repercussions on the entire economic system and leads to a reconfiguration of the underlying capital structure.

Figure 9 illustrates how a change in preference alters the capital structure in the economic system. When the consumer demand changes it is not necessary that this demand is satisfied immediately. Some of the goods which are desired after the change may not be produced yet or their prices are such that certain consumers cannot afford them. Over time, however, a reallocation of resources occurs and new firms come into existence and the desired goods will then be provided. This is what Mises (2008, pp.270) and others have called consumer sovereignty.

Of particular interest is the situation in which the preferences of the households change to the effect that the relation between their overall demand for consumer goods and their overall demand for investment vehicles changes. In this case revenue, sales, and production will be affected in all lines of production. Furthermore, the banks will lower the interest rate if present money becomes more abundant and they will raise it if present money becomes dearer. As a consequence, the financing conditions in the economy will change and firms will be encouraged to either reduce or to enhance their investments. Similarly, if the demand for equity shares changes then the banks will change the price at which firm ownership can be acquired and this changes the propensity to invest by newly created firms. And last but not least a change of the overall profits in the economy affects the possibilities for internal financing.

Let’s consider the case in which the demand for consumer goods falls. With a decline in profits there will be a tendency to lower output in all lines of production and to release factors of production accordingly. But the availability of cheap labor in combination with the abundant money for start-up
firms creates the opportunity to produce certain goods profitably which was
not possible before. In particular, there will now be firms who produce goods
which formerly were outside the capital structure of the economy and they
will find customers in those firms who formerly operated at the highest stages
of production. These firms, who were formerly forced to produce using la-
bor alone will take the opportunity to enhance their productivity. The gains
from the division of labor which are thus achieved at the highest level of
production will subsequently propagate through the entire system by raising
the productivity and lowering prices. As a consequence the unit costs of the
firms fall and because of competition also the offered quantity increases in all
markets. The capital stock of the economy thus grows and the real incomes
of its inhabitants rise. The model thus shows how saving is a precondition
for capital accumulation and economic prosperity.
7 Discussion

7.1 On preferences

Preferences are, in general, a mental tool to organize the thoughts of the economist. Economists have very much become used to these tools and use a static representation of preferences called utility function on almost a daily basis. Those preferences, however, must not be confounded with the preferences spelled out in this model. Within the neoclassical paradigm the preferences of an individual are understood as a static coherent value scale which can be analyzed on the basis of indifference relations. From the Austrian perspective, however, such static preferences stand in contradiction with the reality of human action. As Ludwig von Mises (2008, p.95) states,

“[…] the scale of values or wants manifests itself only in the reality of action. These scales have no independent existence apart from the actual behavior of individuals. The only source from which our knowledge concerning these scales is derived is the observation of a man’s actions.”

For Austrian economists a value scale is only a description of a decision. It describes the fact that in choosing between different options human beings have to compare things which are per se incomparable. Therefore, acting men compare these thing in terms of their capability to satisfy their needs (Mises, 2008, p.119). The comparison of different goods in terms of their serviceableness is the value scale. Before an action takes place there is always a planning phase. Also in this phase value comparisons take place, but these valuations are not final because a person may always change his mind. Only in the moment of action does a value scale become definite. And even then

13Emphasis added.
the only thing that can be said about this scale is that the chosen option has been preferred to all others. The ranking among the other options remains obscure. In fact, at no point in time does a complete value scale even exist. For acting men do not have a fully developed agenda of those actions which they would perform if they were not doing what they are doing.

Furthermore, when Mises refers to actions he also always implies that two actions of an individual can never be synchronous (Mises, 2008, p.102). As a consequence, the value scales of an individual are permanently formed anew. It is thus incorrect to assert that preferences and value scales are constant in time. No individual can ever have static preferences because the value scales that pertain to two different actions are ontologically different objects. Moreover, the continuous reshaping of value scales also precludes a universal transitivity principle (Mises, 2008, p.103).

Given the above, it is clear that the value scales of acting men and of the agents in this model are irreconcilable with the notion of a utility function. The preferences in this model are neither complete, nor continuous, nor transitive and there is thus no coherent preference set which would describe them. This is the reason why the present model uses sequences of preferred choices instead of utility functions.\footnote{For a substantial critique of neoclassical consumer theory see Selikoff (2011). Also see the debate between Caplan (1999), Hülsmann (1999), and Block (1999).}

In the context of this model human action on the part of the households consists in buying or not buying a product and in accepting a contract or refusing it. The agents perform these actions sequentially. The sequences of intended actions list the goods which are, in the course of time, preferred to all other goods. The things which are not chosen and the value scales which constitute these choices remain unknown. In specifying the model the schedules of wants are known to the modeler. But this does not bear a contradiction at all. It only says something about the character of the model.
The model describes the economic constellations that would occur if there were agents who pursued the goals implied in these preferences. The model therefore belongs to the realm of positive economics.

Moreover, the model must be interpreted such that the preferences in this model describe actions which are intended after planning. The decision process itself, which includes an analysis of the personal situation and the formation of expectations, lies outside the scope of this model. The preferences in this model are only the result of such a process. These preferences are not “rationalized”. There is no psychologic element stating that it is advantageous to act or feel this way. All the more, however, these preferences are the expression of the consumers’ wants. They reflect their sovereignty because they need neither be justified nor explained. This also implies that the consistency of the model does not depend on the behavior of the consumers, no matter how this behavior is specified.\textsuperscript{15}

Having said this, it is clear that the preferences and actions in this model are an imaginary construction.\textsuperscript{16} It is impossible to find out whether the population of an economy historically acted according to a given preference setup. Consequently, models of this type cannot be calibrated. And, moreover, since there is no rationality assumption made in connection with these preferences, it is also not possible – as it is practiced in DSGE modeling – to compare the results of such a model with a historical pattern on the basis of the assumption that agents did behave “optimally”. The objective of the present model is only to illustrate the mechanisms that are at work in an economy.

\textsuperscript{15}The Austrian approach to preferences and utility is a priori in line with all behavioral approaches to economics (Holcombe, 2009).

References


Figure 3: Both the real and the monetary quantities of the economy are in constant circular flow. Goods and services are exchanged between firms as well as between firms and households. Both firms and households have monetary relations with their banks. The monetary transactions are recorded by the transaction flow matrix shown in Table 2.
Figure 4: The order of events within one time period.
Figure 5: The results of the model can be viewed in an economic observatory that is implemented as a dynamic graphical interface.
Figure 6: The liquidity management of banks distinguishes between own funds and loanable funds. The former funds are used for interest and dividend payments and they serve as a liquidity buffer. The latter are used to make loans and redemption payments. The sum of loanable funds and outstanding loans can be understood as the lending capacity of banks.
Figure 7: A market is constituted by a list of offers. Each offer can be depicted as a horizontal supply curve of a given length. When combined, these supply curves describe the total quantity that is offered in the market and the price spectrum at which this quantity is offered.
Figure 8: A market from the perspective of an individual buyer. The horizontal supply curves are the offers that he has found in the market. The demand curve captures his reservation price and the fact that purchasing decisions are marginal decisions. A transaction occurs if at least one supply curve intersects with the demand curve.
Figure 9: The consumer preferences need not be identical over consumers and they can change over time. At each point in time there is a distribution of wants to which the economic system must adapt.