Baptiste Massenot

A Business Cycle Model with Neuroeconomic Foundations

Non-Technical Summary

I present a new business cycle model in which decision making follows a simple mental process motivated by neuroeconomics (Fehr and Rangel, 2011). Decision makers first compute the value of two different options (e.g. buy a new car or not) and then choose the option that offers the highest value, but with errors. Compared to standard business cycle models (Woodford, 2003; Gali, 2015), this mental process is computationally easier and more realistic.

I first apply this mental process to a consumption saving decision to derive the aggregate demand. Consumers receive discrete consumption opportunities that give them the option to buy one unit of good. For example, they decide whether to take a cab, have a coffee, take a vacation, etc. On the one hand, they would like to consume these goods because they yield utility. On the other hand, they dislike purchasing these goods because of a thrift motive. Consumers decide to purchase a good if the overall value of consuming it is higher than the value of not consuming it. However, they make errors when comparing these two values and thus decide to consume with a certain probability. A lower thrift, a lower price and a higher wealth increase the likelihood of consumption.

I then apply the mental process to a production decision to derive the aggregate supply. Producers like to sell their goods but dislike the effort required for production. They decide to produce if the value of producing a good is higher than the value of not producing it. A higher price and a lower cost of effort increase production.

I then study common macroeconomic questions in the short run (Keynesian equilibrium with fixed prices) and in the long run (neoclassical equilibrium with flexible prices). A larger money supply or a lower thrift increase aggregate demand. Output increases in the short run and reverts to its initial value in the long run as prices adjust. A productivity shock increases supply. Output increases immediately and prices decrease in the long run. I also present two extensions. First, I introduce a financial market and study shocks to the interest rate. Second, I introduce a government and study the economic consequences of government spending.

Overall, the model yields standard business cycle implications, suggesting that the restrictions on the decision making process are relatively innocuous.

The main difference with standard models is that a demand function in level replaces the traditional Euler equation. First, this implies that consumption is less smooth. Even liquid consumers can have a high marginal propensity to consume. Second, the interest rate does not affect consumption through the conventional intertemporal substitution motive. Instead, it only has an effect in case consumers need to borrow to finance their consumption. A lower interest rate can then stimulate consumption simply because it decreases the cost of borrowing.

The paper contributes to the business cycle literature by developing a highly tractable and intuitive model. The results can be derived in a few straightforward steps and can be understood with standard supply-demand diagrams. The broad business cycle implications are in line with standard models. The subtle differences in consumer behavior are supported by several empirical studies and contribute to the simplicity of the model.

A Business Cycle Model with Neuroeconomic Foundations

Baptiste Massenot[*]

January 31, 2018

Abstract

I present a new business cycle model in which decision making follows a simple mental process motivated by neuroeconomics. Decision makers first compute the value of two different options and then choose the option that offers the highest value, but with errors. The resulting model is highly tractable and intuitive. A demand function in level replaces the traditional Euler equation. As a result, even liquid consumers can have a large marginal propensity to consume. The interest rate affects consumption through the cost of borrowing and not through intertemporal substitution. I discuss the implications for stimulus policies.

1 Introduction

I present a new business cycle model in which decision making follows a simple mental process motivated by neuroeconomics (Fehr and Rangel, 2011). Decision makers first compute the value of two different options (e.g. buy a new car or not) and then choose the option that offers the highest value, but with errors. Compared to standard business cycle models (Woodford, 2003; Galí, 2015), this mental process is computationally easier and more realistic.

I first apply this mental process to a consumption saving decision to derive the aggregate demand. Consumers receive discrete consumption opportunities that give them the option to buy one unit of good. For example, they decide whether to take a cab, have a coffee, take a vacation, etc. On the one hand, they would like to consume these

goods because they yield utility. On the other hand, they dislike purchasing these goods because of a thrift motive. Consumers decide to purchase a good if the overall value of consuming it is higher than the value of not consuming it. However, they make errors when comparing these two values and thus decide to consume with a certain probability. A lower thrift, a lower price and a higher wealth increase the likelihood of consumption. Assuming a continuum 1 of consumers, the aggregate demand is simply equal to the probability of consumption.

I then apply the mental process to a production decision to derive the aggregate supply. Producers like to sell their goods but dislike the effort required for production. They decide to produce if the value of producing a good is higher than the value of not producing it. A higher price and a lower cost of effort increase production.

I then study common macroeconomic questions in the short run (Keynesian equilibrium with fixed prices) and in the long run (neoclassical equilibrium with flexible prices). A larger money supply or a lower thrift increase aggregate demand. Output increases in the short run and reverts to its initial value in the long run as prices adjust. A productivity shock increases supply. Output increases immediately and prices decrease in the long run. I also present two extensions. First, I introduce a financial market and study shocks to the interest rate. Second, I introduce a government and study the economic consequences of government spending.

Overall, the model yields standard business cycle implications, suggesting that the restrictions on the decision making process are relatively innocuous.

The main difference with standard models is that a demand function in level replaces the traditional Euler equation. First, this implies that consumption is less smooth. Even liquid consumers can have a high marginal propensity to consume, consistent with several empirical studies (Jappelli and Pistaferri, 2014; Olafsson and Pagel, 2016; Fagereng et al., 2016). Policies that temporarily increase the income of consumers (e.g. a fiscal transfer or a helicopter drop of money) can effectively stimulate the economy. By contrast, standard models feature excessive consumption smoothing (Jappelli and Pistaferri, 2010) and typically rely on hand-to-mouth or illiquid consumers to increase the sensitiv-

ity of consumption to income shocks (Campbell and Mankiw, 1989; Kaplan and Violante, 2014).

Second, the interest rate does not affect consumption through the conventional intertemporal substitution motive. Instead, it only has an effect in case consumers need to borrow to finance their consumption. A lower interest rate can then stimulate consumption simply because it decreases the cost of borrowing. Consistent with this implication, Gross and Souleles (2002) find a significant effect of the interest rate on consumer debt while Cloyne et al. (2016) find no effect on consumer spending.[1]

The paper contributes to the business cycle literature by developing a highly tractable and intuitive model. The results can be derived in a few straightforward steps and can be understood with standard supply-demand diagrams. The broad business cycle implications are in line with standard models. The subtle differences in consumer behavior are supported by several empirical studies and contribute to the simplicity of the model.

The paper is related to the strand of macroeconomics that restricts cognitive skills. In these models, agents may be rationally inattentive (Sims, 2003; Maćkowiak and Wiederholt, 2009, 2015; Gabaix, 2016a,b; Saint-Paul, 2017), follow rules of thumb (Akerlof and Yellen, 1985; Campbell and Mankiw, 1989; Lettau and Uhlig, 1999; Winter et al., 2012), form naive expectations (Brock and Hommes, 1997; Branch and Evans, 2006; Fuster et al., 2010; De Grauwe, 2012) or have limited levels of reasoning (Cornand and Heinemann, 2015; Angeletos and Lian, 2017; Farhi and Werning, 2017).

Finally, the simple mental process I rely on abstracts from several dimensions relevant to neuroeconomics. For example, Woodford (2016) and Fudenberg et al. (2015) explicitly formalize the dynamics of evidence accumulation that leads to stochastic choice. Laibson (1997), Gul and Pesendorfer (2004), Loewenstein and O'Donoghue (2004), Benhabib and Bisin (2005), Levine and Fudenberg (2006), Amador et al. (2006), and Krusell et al. (2010) study consumption saving decisions in more detailed models that explicitly consider the conflicting objectives of different selves.

---

[1]This holds for outright home owners but not for mortgage holders, who experience an additional income effect through a change in their mortgage payments. This effect is also unrelated to intertemporal substitution.

Section 2 introduces a generic decision making process that is then applied to a consumption-saving decision in section 3 and to a production decision in section 4. Section 5 analyzes the neoclassical equilibrium and section 6 the Keynesian equilibrium. Section 7 introduces a financial market and studies monetary policy. Section 8 introduces a government and studies fiscal policy. Section 9 concludes.

2 Decision Making

This section introduces the simple mental process that agents will follow when making decisions. The process aims to integrate several insights from neuroeconomics and has been applied to a wide range of economic decisions (Fehr and Rangel, 2011). The brain of the decision maker computes a value for each option available. This value integrates information about the attributes of each option and their attractiveness. Finally, the brain makes errors when comparing the values of the different options. As a result, decisions are noisy, that is, for a given choice, given preferences, and a given environment, the decision maker will not always make the same decision. Here, I abstract from the dynamic process of accumulation of noisy evidence that leads to noisy decisions (Woodford, 2016; Fudenberg et al., 2015) and directly assume that decision makers make errors when comparing values.

Decision makers choose between different options that differ along several dimensions indexed by i. The value v of option x is then equal to the weighted average of the value of each dimension $d_i(x)$, that is:

$$v(x) = \sum \alpha_i d_i(x),$$

where α_i is the weight attached to dimension i.

The agent then chooses the option with the highest value but with some error. If there are two options, x and y, the individual then compares $v(x)$ to $v(y)$. He chooses x if:

$$v(x) - v(y) > \epsilon,$$

4

where ϵ is a random variable drawn from the cumulative distribution function F, with mean 0, and that is identically and independently distributed across decisions and decision makers. Thus, choice is stochastic. The probability of choosing x is $F[v(x) - v(y)]$. The more attractive x is relative to y, the higher the probability of choosing x.

3   Demand

Demand is captured by individual consumption-saving decisions. The model aims to capture the following simple tradeoff. Consumers like consuming but dislike spending because of a thrift motive.

Within a period, a continuum 1 of consumers receives a continuum 1 of consumption opportunities. For each consumption opportunity, a consumer decides whether to consume 1 unit or not. Consuming yields utility u while not consuming yields utility 0. Consuming also decreases the monetary wealth w (measured at the beginning of each period) by the price p while not consuming leaves the wealth intact. The ratio $-p/w$ measures the extent to which wealth is reduced. The disutility attached to a reduction in wealth is $-\sigma p/w$, where σ measures thrift. Consuming hurts thriftier consumers more. A higher price and a lower wealth make consuming less attractive. When wealth approaches 0, the disutility of consumption becomes infinite.

The value attached to consuming is $u - \sigma p/w$ while the value attached to not consuming is 0. Consumers choose the option that yields the highest value but they make errors in the process. They decide to consume if $u - \sigma p/w > \epsilon$. As a result, the probability of consumption is $F(u - \sigma p/w)$.

Since there is a continuum 1 of consumers, the aggregate demand is equal to the probability of consumption

$$D = F(u - \sigma p/w).$$

Since F is increasing, the aggregate demand D increases with wealth w and utility u, and decreases with the price p and thrift σ.

Overall, this demand function has standard properties. It replaces the Euler equation

in standard models, that relates consumption growth to the discount rate, the interest rate, and expected inflation. This difference arises because consumers have a different objective function. First, they do not explicitly consider the implications of the consumption decisions on their future consumption. Instead, thrift implicitly captures the concerns about future consumption. Second, consumers face a discrete choice and not a continuum. This implies that the utility of consumption is simply captured by a utility parameter instead of the traditional concave utility function.

The main implication is that consumers have a weaker consumption smoothing motive and thus can have a large marginal propensity to consume (MPC) out of an unexpected income shock. The MPC tells us how much consumer spending increases following an increase in wealth of one monetary unit. It is given by:

$$MPC = \partial pD / \partial w = f(u - \sigma p / w) \sigma p^2 / w^2,$$

where f is the probability density function associated with F. I focus on the case of a desirable consumption opportunity, that is, $u > \sigma p / w$. Since f is centered in 0 and assuming a standard hump-shaped density function, a desirable consumption opportunity implies that we are in the decreasing part of f. The model can predict a wide range of MPCs depending on parameter values. In particular, the MPC increases with the level of thrift σ and decreases with wealth w. The intuition is that not so thrifty or wealthy consumers already have exhausted their consumption opportunities and a higher wealth can thus only have a minimal impact. Several empirical studies support these predictions (Jappelli and Pistaferri, 2014; Olafsson and Pagel, 2016; Fagereng et al., 2016). Abstracting for now from general equilibrium considerations, this implies that policies that increase the wealth of consumers (e.g. a fiscal transfer or a helicopter drop of money) can effectively stimulate the economy. The main difference with standard models is that the MPC can be large, even when consumers are liquid. By contrast, the strong smoothing motive in standard models forces the MPC to stay close to 0, unless consumers are illiquid or hand-to-mouth (Campbell and Mankiw, 1989; Kaplan and Violante, 2014).

Another difference is that the demand function does not depend on future prices or on the interest rate. This is because I assume that consumers do not explicitly think about the future consequences of their current consumption decisions. However, a simple reinterpretation of the thrift parameter makes the demand function look almost like an Euler equation. Assume that consumers save the price p if they decide not to consume and that this allows them to derive the additional utility $p(1 + r)u'/p'$ the next period, where r is the interest rate, p' is the future price, and u' is the discounted utility of future consumption. Thus, they decide to consume if $u - p(1 + r)u'/p' > \epsilon$. Replacing $\sigma = (1 + r)u'/p'$ yields the same condition as above. The only difference is that σ now depends on future prices, the interest rate and the discount factor, in a way similar to the Euler equation. Another possible interpretation is that consumers do not pay attention to future prices and the interest rate and consider these variables to be constant (Maćkowiak and Wiederholt, 2015; Gabaix, 2016a).

4 Supply

The production decisions determine the supply side of the economy. Each period, a continuum 1 of producers (who are the same people as the consumers) faces a continuum 1 of production decisions. Producers tradeoff the cost of providing effort e against the benefit pu/P of selling their product at price p, where P is the average price in the economy. Producers then decide to produce if $pu/P - e > \epsilon$, that is, with probability $F(pu/P - e)$. The probability of production increases with the individual price p and with the utility of consumption u, and decreases with the average price P and with the cost of effort e. This individual supply decision is similar in spirit to the optimality condition related to labor supply in standard business cycle models.

Since there is a continuum 1 of producers and since all producers and goods are symmetric, we have $p = P$ and the aggregate supply is equal to:
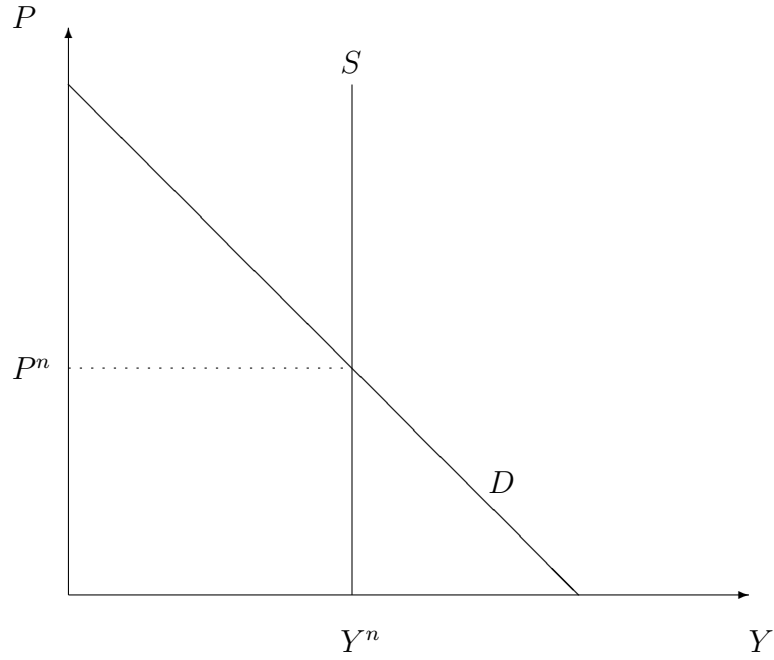
$$S = F(u - e).$$

Figure 1: Equilibrium

The aggregate supply is increasing in the utility u and decreasing in the cost of effort e. It is independent of the level of prices P.

5 Neoclassical Equilibrium

The neoclassical equilibrium is defined by a price P^n and output Y^n such that supply is equal to demand $S = D$. Since the supply S is independent of prices, the equilibrium output is:

$$Y^n = F(u - e).$$

The equilibrium condition $S = D$ implies $F(u - \sigma P^n/w)c = F(u - e)$ and yields the equilibrium price:

$$P^n = ew/\sigma.$$

It is increasing in wealth w and in the cost of effort e, and it decreasing in thrift σ.

Figure 1 graphically represents the supply and demand functions. The equilibrium is represented by the intersection of these two lines.

In equilibrium, consumers spend $P^n Y^n$ and earn $P^n Y^n$ as producers within the same
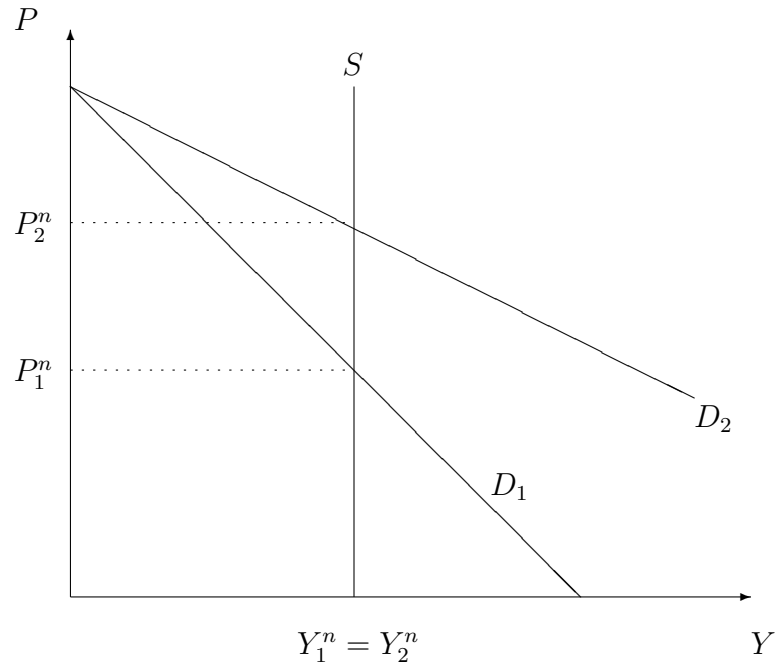
8

Figure 2: New equilibrium when demand increases from D_1 to D_2 (lower thrift or higher wealth)

period. As a result, their wealth w stays constant.

An increase in the wealth w of consumers (e.g. helicopter drop of money) increases demand. This effect is represented in Figure 2 by a switch from D_1 to D_2. Equilibrium prices increase. The higher price motivates producers to increase supply. However, since all prices increase at the same time, producers do not receive additional benefit from selling their products and are thus not willing to provide more effort. As a result, the equilibrium production stays constant.

A lower thrift σ also increases demand. This effect can also be represented in Figure 2 by a switch from D_1 to D_2. Equilibrium prices increase while production stays constant. This experiment has a similar interpretation as the paradox of thrift (Keynes, 1936; Eggertsson and Krugman, 2012). Consumers become thriftier and thus want to save more. Since all consumers spend less at the same time, their earnings decrease at the same time. Thus, they do not save more even though they spend less.

A higher productivity (a lower e) increases supply. This effect is represented in Figure 3 by a switch from S_1 to S_2. Producers are willing to provide more effort given the price they receive for their output. Output thus increases. Since demand does not change,
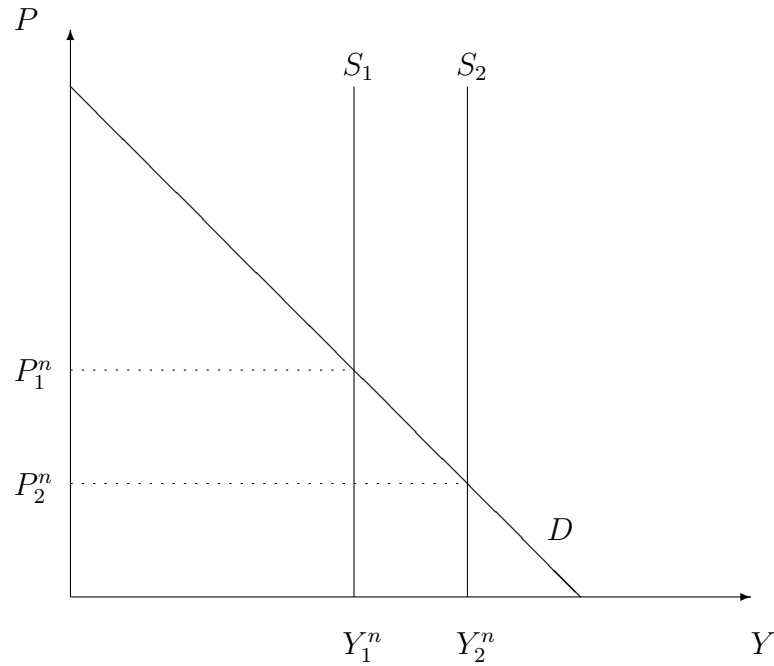
Figure 3: New equilibrium when supply increases from S_1 to S_2 (higher productivity)

equilibrium prices have to decrease at the same time.

6 Keynesian Equilibrium

I now study a Keynesian equilibrium that is useful to study how the economy responds in the short run to an unexpected shock.

Like in standard New Keynesian business cycle models, the main difference with the neoclassical world is that prices are rigid in the short run and that producers may not be able to adjust their prices to match their desired level of production. Producers first post a price p such that the expected demand for their product at this price $D(p)$ corresponds to their desired level of production $S(p)$. An unexpected demand shock may hit the economy after prices have been posted, resulting in a realized demand $\tilde{D}(p)$. (An unexpected supply shock does not affect the Keynesian equilibrium.) To ensure that markets clear, producers have to satisfy this realized demand even if it does not correspond to their desired level of production.

Because goods and producers are identical, all goods trade at the same price $p = P$. This implies that the desired level of production is $F(u - e)$.

The Keynesian equilibrium is defined by a price P^k and output Y^k such that expected demand is equal to the desired supply $D(P^k) = F(u - e)$ and such that the realized demand at this price is satisfied, that is, $Y^k = \tilde{D}(P^k)$. The first condition is the same condition as in the neoclassical equilibrium, so the equilibrium price is the same:

$$P^k = P^n = ew/\sigma.$$

The equilibrium level of output is then

$$Y^k = \tilde{D}(ew/\sigma).$$

If the realized demand is equal to the expected demand $\tilde{D} = D$, the Keynesian and the neoclassical equilibria coincide.[2] This case is represented in Figure 4.

An unexpected demand shock $\tilde{D} \neq D$ (e.g. a surprise change in thrift or wealth) introduces a difference between the Keynesian and the neoclassical equilibrium output. An unexpected positive demand shock increases output in the Keynesian equilibrium while a negative unexpected shock decreases it. The case of surprise drop in demand is illustrated in Figure 5.

7   Monetary Policy

I now introduce a simple credit market to introduce a more realistic form of monetary policy that shifts the interest rate. With probability γ, consumers are illiquid. They do not have enough liquidity to finance their consumption opportunity. The illiquidity may arise, for example, because of an unspecified timing mismatch between income and spending. To solve this liquidity problem, the consumer can borrow at the interest rate r. To keep things simple, I assume that there is no default and that the debt is repaid at the end of the period.

---

[2]Unlike standard New Keynesian models, the price-making assumption does not enable producers to charge a markup over the marginal cost and thus does not distort output. The reason is that all the goods are similar and thus trade at the same price.
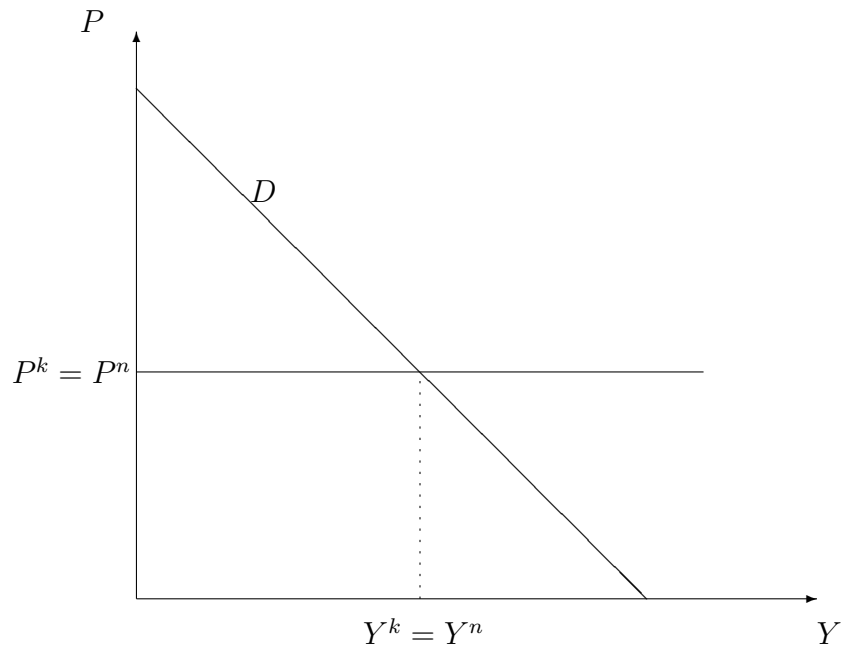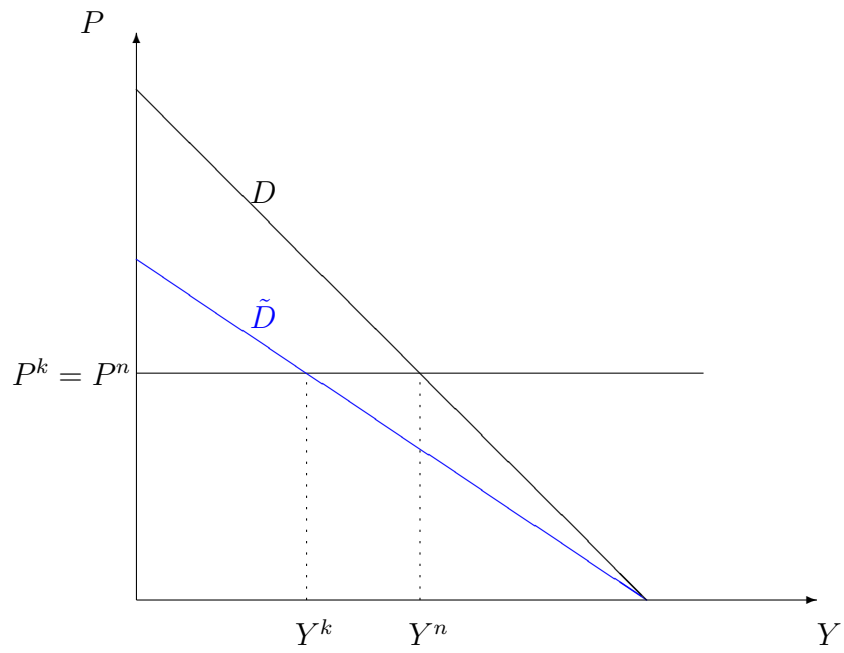
Figure 4: Keynesian equilibrium

Figure 5: Keynesian equilibrium with unexpected demand shock

The consumer then has to pay the price p with probability $1 - \gamma$ and $p(1 + r)$ with probability γ. Aggregate demand becomes

$$D = \gamma F(u - \sigma p(1 + r)/w) + (1 - \gamma)F(u - \sigma p/w).$$

It depends negatively on the price p, the interest rate r and on illiquidity γ.

Since consumers suffer from illiquidity equally from all goods, we still have in equilibrium that all goods trade at the same price, that is, $p = P$. This implies that the equilibrium output is unaffected by the presence of a credit market and is still equal to

$$Y^n = F(u - e).$$

To find the equilibrium price, we again use the neoclassical equilibrium condition $S = D$, which implies $\gamma F(u - \sigma p(1 + r)/w) + (1 - \gamma)F(u - \sigma p/w) = F(u - e)$. To find a closed form solution, we assume that F follows a uniform distribution. This yields:

$$P^n = \frac{ew}{\sigma(1 + \gamma r)}.$$

The equilibrium price depends negatively on illiquidity γ and on the interest rate r. A higher interest rate makes it more expensive to buy the good and thus decreases its demand. The equilibrium price then decreases. For a given interest rate r, a higher degree of illiquidity means that consumers will more often have to finance their consumption with credit. Since credit increases the cost of buying the good, it also decreases demand and thus the equilibrium price. If consumers are never illiquid ($\gamma = 0$) or if the interest rate is equal to 0, the equilibrium price is the same as in the benchmark model.

We can also study the Keynesian equilibrium. Let us consider a central bank that can create a surprise change in the interest rate from r to $\tilde{r}$ after prices have been posted. As before, the equilibrium price is unaffected, that is, we have

$$P^k = P^n = \frac{ew}{\sigma(1 + \gamma r)}.$$

The Keynesian equilibrium level of production is now equal to the realized demand $\tilde{D}$ at the posted price P^k:

$$Y^k = F(u - \frac{1 + \gamma r}{1 + \gamma \tilde{r}} e).$$

If the central bank implements the expected level of interest rate $\tilde{r} = r$, then the equilibrium output is equal to its neoclassical level. If the central bank unexpectedly increases (decreases) the interest rate, the Keynesian equilibrium level of output is higher (lower) than the neoclassical level.

Note that everybody lends and borrows the same amount, so the introduction of a financial market does not affect wealth accumulation. It still stays constant and the same for everyone.

Although monetary policy has the same consequences as in standard models, it works differently. In standard models, the interest rate affects consumption through the Euler equation. Consumers realize that if they spend less today, they can save more, receive interests on these additional savings, and thus consume more tomorrow. A lower interest rate then makes it less profitable to postpone consumption and thus increases consumption today. By contrast, a lower interest rate in this model works through a more straightforward cost of borrowing motive and only has an effect on consumption when consumers have to borrow to finance their consumption. Consistent with this implication, Gross and Souleles (2002) find a significant effect of changes in the interest rate on consumer debt. By contrast, Cloyne et al. (2016) find that outright home owners do not adjust their spending following a negative interest rate shock. Mortgage holders increase their consumption, presumably because their mortgage payments decrease and their disposable income thus increases. However, this latter effect is also unrelated to intertemporal substitution and is not present in my model because debt matures at the end of each period.

8 Fiscal Policy

I now introduce a government. The government buys G goods from all producers and levies lump-sum taxes $T = PG$.

To find the neoclassical equilibrium, we use the new market clearing condition $S = D + G$. Government spending does not affect the supply decisions of producers:

$$Y^n = F(u - e).$$

The equilibrium price is then given by $F(u - e) = F(u - \sigma p/w) + G$. To find a closed form solution, assume again that F is uniform with support $[-a, a]$. This yields:

$$P^n = (e + g)w/\sigma,$$

where $g = G/2a$.

Government spending does not affect the neoclassical level equilibrium output in this model. The additional demand, however, naturally increases equilibrium prices. The government spending multiplier $\partial Y^n / \partial G$ is thus equal to 0. Government spending perfectly crowds out private consumption. The reason is that producers are providing the level of effort they desire and respond to a higher demand by increasing prices. Since all prices increase at the same time, the producers are not willing to provide more effort.

In the Keynesian equilibrium, however, government spending can have real consequences. Producers now post the price $P^k = P^n$. If the government implements a surprise change in government spending, then producers will have to adjust their production to the new demand without being able to immediately adjust their price. Let $\tilde{G}$ be the realized level of government spending. Then, the Keynesian equilibrium level of production is given by.

$$Y^k = Y^n + \tilde{G} - G.$$

A surprise change in government spending moves output one for one. Output is now equal to its neoclassical level plus the difference between the realized level of government

spending and its expected level. The spending multiplier is 1.

Government spending is financed by raising lump sum taxes T equal to government spending PG. Agents now earn $PY + G$ and spend $PY + T$. Since $T = PG$, their wealth stays constant.

The results on the government spending multiplier are in line with the literature. For example, Woodford (2011) obtains a multiplier equal to 1 in an analytically simple New Keynesian model. In the neoclassical case, he finds a multiplier that is between 0 and 1 while I find it to be 0. However, his multiplier converges to 0 as his utility function becomes more linear, which would be the case the most similar to a discrete choice environment.

9   Conclusion

I develop a simple business cycle model in which agents make decisions by following a simple mental process motivated by neuroeconomics. The resulting model is highly tractable, intuitive, and yields reasonable predictions.

References

Akerlof, G. A. and Yellen, J. L. (1985). A near-rational model of the business cycle, with wage and price inertia. *The Quarterly Journal of Economics*, 100:823–838.

Amador, M., Werning, I., and Angeletos, G.-M. (2006). Commitment vs. flexibility. *Econometrica*, 74(2):365–396.

Angeletos, G.-M. and Lian, C. (2017). Dampening general equilibrium: From micro to macro. *Working paper*.

Benhabib, J. and Bisin, A. (2005). Modeling internal commitment mechanisms and self-control: A neuroeconomics approach to consumption–saving decisions. *Games and economic Behavior*, 52(2):460–492.

Branch, W. A. and Evans, G. W. (2006). Intrinsic heterogeneity in expectation formation. *Journal of Economic theory*, 127(1):264–295.

Brock, W. A. and Hommes, C. H. (1997). A rational route to randomness. *Econometrica*, pages 1059–1095.

Campbell, J. Y. and Mankiw, N. G. (1989). Consumption, income, and interest rates: Reinterpreting the time series evidence. *NBER macroeconomics annual*, 4:185–216.

Cloyne, J., Ferreira, C., and Surico, P. (2016). Monetary policy when households have debt: new evidence on the transmission mechanism. *Working paper*.

Cornand, C. and Heinemann, F. (2015). Limited higher order beliefs and the welfare effects of public information. *Journal of Economic Studies*, 42(6):1005–1028.

De Grauwe, P. (2012). Booms and busts in economic activity: A behavioral explanation. *Journal of Economic Behavior & Organization*, 83(3):484–501.

Eggertsson, G. B. and Krugman, P. (2012). Debt, deleveraging, and the liquidity trap: A fisher-minsky-koo approach. *The Quarterly Journal of Economics*, 127(3):1469–1513.

Fagereng, A., Holm, M. B., and Natvik, G. J. (2016). Mpc heterogeneity and household balance sheets. *Working paper*.

Farhi, E. and Werning, I. (2017). Monetary policy, bounded rationality, and incomplete markets. *Working paper*.

Fehr, E. and Rangel, A. (2011). Neuroeconomic foundations of economic choice – recent advances. *The Journal of Economic Perspectives*, 25(4):3–30.

Fudenberg, D., Strack, P., and Strzalecki, T. (2015). Stochastic choice and optimal sequential sampling. *Working paper*.

Fuster, A., Laibson, D., and Mendel, B. (2010). Natural expectations and macroeconomic fluctuations. *The Journal of Economic Perspectives*, 24(4):67–84.

Gabaix, X. (2016a). Behavioral macroeconomics via sparse dynamic programming. *Working paper*.

Gabaix, X. (2016b). A behavioral new keynesian model. *Working paper*.

Galí, J. (2015). *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*. Princeton University Press.

Gross, D. B. and Souleles, N. S. (2002). Do liquidity constraints and interest rates matter for consumer behavior? evidence from credit card data. *The Quarterly journal of economics*, 117(1):149–185.

Gul, F. and Pesendorfer, W. (2004). Self-control and the theory of consumption. *Econometrica*, 72(1):119–158.

Jappelli, T. and Pistaferri, L. (2010). The consumption response to income changes. *Annu. Rev. Econ.*, 2(1):479–506.

Jappelli, T. and Pistaferri, L. (2014). Fiscal policy and mpc heterogeneity. *American Economic Journal: Macroeconomics*, 6(4):107–136.

Kaplan, G. and Violante, G. L. (2014). A model of the consumption response to fiscal stimulus payments. *Econometrica*, 82(4):1199–1239.

Keynes, J. M. (1936). *General theory of employment, interest and money*. Atlantic Publishers & Dist.

Krusell, P., Kuruşçu, B., and Smith, A. A. (2010). Temptation and taxation. *Econometrica*, 78(6):2063–2084.

Laibson, D. (1997). Golden eggs and hyperbolic discounting. *The Quarterly Journal of Economics*, 112(2):443–478.

Lettau, M. and Uhlig, H. (1999). Rules of thumb versus dynamic programming. *American Economic Review*, pages 148–174.

Levine, D. and Fudenberg, D. (2006). A dual-self model of impulse control. *American Economic Review*, 96(5):1449–1476.

Loewenstein, G. and O'Donoghue, T. (2004). Animal spirits: Affective and deliberative processes in economic behavior. *Working paper*.

Maćkowiak, B. and Wiederholt, M. (2009). Optimal sticky prices under rational inattention. *The American Economic Review*, 99(3):769–803.

Maćkowiak, B. and Wiederholt, M. (2015). Business cycle dynamics under rational inattention. *The Review of Economic Studies*, 82(4):1502–1532.

Olafsson, A. and Pagel, M. (2016). The liquid hand-to-mouth: Evidence from personal finance management software. *Working paper*.

Saint-Paul, G. (2017). A quantized approach to rational inattention. *European Economic Review*, 100:50–71.

Sims, C. A. (2003). Implications of rational inattention. *Journal of monetary Economics*, 50(3):665–690.

Winter, J. K., Schlafmann, K., and Rodepeter, R. (2012). Rules of thumb in life-cycle saving decisions. *The Economic Journal*, 122(560):479–501.

Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy.* Princeton University Press.

Woodford, M. (2011). Simple analytics of the government expenditure multiplier. *American Economic Journal: Macroeconomics*, 3(1):1–35.

Woodford, M. (2016). Optimal evidence accumulation and stochastic choice. Working paper.

Recent Issues