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ABSTRACT

Major depressive disorder (MDD) is one of the most prevalent mental illnesses worldwide. Existing evidence suggests that it has both economic causes and consequences, such as unemployment. However, depression has not received significant attention in the economics literature. In this paper, we present a simple model which predicts the core symptoms of depression from economic primitives, i.e. beliefs. Specifically, we show that when exogenous shocks cause an agent to have pessimistic beliefs about the returns to her effort, this agent will exhibit depressive symptoms such as undereating or overeating, insomnia or hypersomnia, and a decrease in labor supply. When these effects are strong enough, they can generate a poverty trap. We present descriptive evidence that illustrates the predicted relationships.

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1 Introduction

Major depressive disorder (MDD; henceforth simply “depression”) is one of the leading causes of disease burden worldwide, second only to lower back pain in terms of years lost to disability (Vos et al. 2012). The cross-sectional prevalence is an estimated four to five percent of the global population at a given time (Vos et al. 2012; Steel et al. 2014), and lifetime prevalence averages 13 percent across a sample of 18 countries (Bromet et al. 2011; see Kessler and Bromet 2013 for a review). The economic costs of depression from lost productivity have been estimated at around €76bn in Europe (Sobocki et al. 2006) and \$31bn in the United States (Stewart et al. 2003).

Given this high prevalence, the significant economic cost, and economists’ interest in other psychiatric conditions such as substance abuse (Becker and Murphy 1988), it is perhaps surprising that depression has not received greater attention in the economics literature. The goal of this paper is to make a contribution towards understanding depression through the lens of economics. We present a stylized model which asks whether and which symptoms of depression can be predicted by changes in economic primitives, in particular beliefs. In our model, a decision-maker is exposed to an exogenous negative outcome, which leads her to update her beliefs about the returns to her labor effort. We show that this change in beliefs can generate a set of behaviors that are characteristic of depression.

Our focus in explaining depression is on incorrect beliefs about the returns to effort. This choice is motivated by the fact that pessimism is a defining core symptom of depression. Aaron Beck, one of the foremost theorists on depression in psychiatry, grouped the symptoms of depression broadly into four categories, which he termed cognitive, motivational, emotional, and somatic, respectively (Beck 1967). First, patients exhibit hopelessness and pessimistic beliefs about the future, themselves, and the world.¹ Second, they are impaired in their motivation and ability to perform everyday activities. Importantly from the economist’s perspective, this impairment extends to functioning in the workplace in terms of decreased labor supply. Third, patients experience dejected mood, an inability to derive pleasure from everyday activities, and a loss of social relationships. Finally, depression is associated with changes in sleeping and eating patterns: patients either gain or lose weight (Fernstrom 1989), and they either exhibit an increase or a decrease in sleep duration

¹This classic group of symptoms is known as the Beck’s “cognitive triad”.

(Jones et al. 1987).²

In this paper, we argue that this complex symptomatology can be parsimoniously understood as the consequence of downward shocks in the beliefs about returns to effort. In our model, a person is depressed if a shock, such as a stressful negative life event that they thought was under their control, causes them to revise downward this belief.³ The decision-maker then chooses labor effort, non-food consumption, food consumption, and sleep. The downward revision in their beliefs naturally delivers the four groups of symptoms described above: first, it leads to pessimism about the future. Second, it decreases the individual’s incentive to exert effort; thus, labor supply falls. Third, the combination of these effects leads to a drop in income, overall consumption, and hence utility, leading to depressed mood. Fourth, pessimistic beliefs about the returns to effort also affect behaviors complementary to effort. Sleeping and eating are prominent examples of such behaviors, and they display a bidirectional response in depression: most patients eat and sleep less, while others eat and sleep more. We show that in our model, depressed individuals can exhibit such behavior by reverting toward their “natural tendencies”: over-eaters and over-sleepers find themselves eating and sleeping more, while under-eaters and under-sleepers find themselves eating and sleeping less. They also consume more temptation goods and invest less in human capital. Fifth, in the extreme, the mechanism can generate a poverty trap when a depressed person reduces her labor effort to zero, which causes them to cease learning about the return to effort, an effect similar in spirit to the findings of, among others, Piketty (1995) and Ali (2011). It is not so much that the depression has reduced their ability to be productive, but has instead undermined their motivation.

²Beck’s classic text on depression describes two additional categories of symptoms, i.e. delusions and hallucinations which might be seen as extreme versions of the remaining groups of symptoms.

³The choice to model depression as a consequence of shocks is based on existing evidence suggesting that negative shocks can adversely affect mental health, and in particular, increase the incidence of depression. We provide a detailed summary of this literature in an Appendix, and an overview here.

Several studies have used quasi-experimental methods, e.g. plant closures, to show that unemployment and fear of unemployment leads to reductions in mental well-being and increases in depression symptoms (Clark 2003; Marcus 2013; Farré, Fasani, and Mueller 2015; Colantone, Crinò, and Ogliari 2015). Similarly, negative wealth shocks, e.g. due to stock market fluctuations, have been shown to affect scores on depression questionnaires such as the CES-D (McInerney, Mellor, and Nicholas 2013; Schwandt 2015). Similar results have been reported for exposure to, and fear of, crime (Cornaglia, Feldman, and Leigh 2014; Dustmann and Fasani 2015), and shocks to relative social status, e.g. by experimentally induced moving among neighborhoods such as in the Moving to Opportunity study (Clark 2003; Katz, Kling, and Liebman 2001; Kling, Liebman, and Katz 2007; Ludwig et al. 2012).

We do not presume to have all the answers. In the tradition of applied economic research our model focuses on a single mechanism—belief shocks—and on simple economic outcomes—static labor supply, income, and a few categories of consumption. We do not attempt to explain every nuance of the causes, symptoms or consequences of depression, some might be more naturally thought of as shocks to preferences or constraints, or to beliefs about other parameters. We nevertheless find it striking how consistent our one simple mechanism is with many of the facts. We think of this paper as a first step toward a richer economic approach to thinking about depression, both theoretically and empirically.

Our approach is similar in spirit to the work of Becker and Murphy (1988) on addiction, in the sense that we model the symptoms of depression as the result of decision-makers optimally choosing consumption bundles given their beliefs and preferences. However, it differs importantly from the rational addiction literature in two ways. First, in our model, becoming depressed is not a choice in the way becoming addicted is in the rational addiction literature, but is the consequence of an exogenous negative shock. Thus, there is no sense in our model in which the depressed individual chooses to be depressed. Second, in our model, individuals have incorrect beliefs about the world, in particular the returns to effort. Our model therefore does not impose the same demands of full information and accurate beliefs as the rational addiction framework; this feature leaves room for intervention to the clinician and policymaker.

A related advantage of our model is that it resonates with prominent psychological and psychiatric theories of depression, and the therapeutic approaches to which they gave rise. An early account of depression in the tradition of the behaviorist B. F. Skinner was provided by the psychologist Charles Ferster, who argued that depression resulted from an overexposure to negative reinforcement and underexposure to positive reinforcement in the environment (Ferster 1973). This view led to the development of Behavioral Activation therapy, which focuses on exposing the patient to positive reinforcement. While today's treatment approaches are different, Ferster's account of the etiology of depression is in line with how we model depression here, namely as a consequence of exposure to negative shocks.

When the cognitive revolution in psychology shifted the focus from simple stimulus-response contingencies in the tradition of Skinner to the cognitive processes that mediate an individual's responses, the classic work of the psychiatrist Aaron Beck suggested that a core reason for depression is distorted thinking (Beck 1967). Cor-

recting such distorted thoughts is still a central element in the standard therapeutic tool to treat depression, Cognitive Behavioral Therapy (CBT). In our model, inaccurate beliefs about the returns to labor effort are an example of such distorted beliefs, and the focus of CBT on correcting such beliefs may explain its effectiveness.

The remainder of the paper is organized as follows. Section 2 attempts to describe the symptoms of depression in the language of economics. Section 3 presents empirical data illustrating the relationships predicted by the model. Section 4 develops the model. Section 5 concludes.

2 Describing depression in the language of economics

In this section, we make an attempt to describe the symptoms of depression in the language of economics. The goal of this exercise is to see to what extent we can distill the complex symptomatology of depression down to economic primitives, in particular, beliefs, preferences, and constraints. We mainly use the comprehensive list of symptoms provided by Beck (1967), and in the entire following section we paraphrase heavily from his exposition. Beck's list of symptoms was originally compiled by generating a list of candidate symptoms from textbooks and monographs; conducting a pilot test comparing the presence of the individual symptoms in 50 depressed patients and 30 non-depressed patients; constructing an inventory consisting of items relevant to depression and pre-testing it on 100 patients; and finally, presenting the revised inventory to 966 psychiatric patients, of which 224 had no depression, and 297, 360, and 85 patients had mild, moderate, and severe depression, respectively.⁴

The other obvious candidate list of depression symptoms are the diagnosis criteria presented in standard diagnostic manuals, such as the DSM-5 in the United States. However, these symptoms are a subset of those described by Beck; we therefore focus on his more comprehensive list, and mention in our discussion which of these symptoms are also used as diagnosis criteria. In addition, the DSM-5 diagnosis criteria are listed in the Appendix.

⁴Beck leaves open the question how these patients were diagnosed as depressed, and how severity was assessed; the standard tool is the clinical interview which tests for the presence of depression symptoms, so it is likely that there is a degree of circularity in the list of symptoms.

2.1 “Cognitive” symptoms

The *cognitive* symptoms of depression describe a set of negative beliefs and attitudes towards oneself and the environment; distorted “notions of causality”, in which patients blame themselves for problems; and indecisiveness. Specifically, Beck describes five such symptoms: first, depressed individuals have *low self-evaluation* or self-esteem; i.e. they feel that they are inadequate and not performing well, including in their financial lives, e.g. feeling that they are impoverished. Second, they have *negative expectations* about the future; “a pattern of expecting the worst and rejecting the possibility of any improvement”. Third, patients engage in *self-blame and self-criticism* because of their “egocentric notions of causality” cause them to “ascribe adverse occurrences to some deficiency in themselves”.⁵ Fourth, patients exhibit *indecisiveness*, i.e. are unable to make even simple decisions. The reason for this inability is that “[d]epressed patients anticipate making the wrong decision: whenever they consider one of various possibilities they tend to regard it as wrong and think they will regret making that choice.” Finally, patients suffer from *distortion of body image*, thinking that they are unattractive. For instance, a man might “worr[y] incessantly about the beginnings of hair loss, convinced that women find him unattractive.”

These cognitive symptoms are closely congruous with the core assumption our model makes, i.e. that depressed patients have pessimistic beliefs about the returns to effort. Specifically, a patient with negative expectations about the future and egocentric notions of causality would believe precisely that her actions led to undesirable outcomes. This, in turn, would generate self-blame and self-criticism and result in low self-evaluation. It is also easy to see how such beliefs would lead to indecisiveness because patients are worried about their actions leading to bad outcomes. Finally, the distortion of body image, e.g. the belief that one is unattractive, could be conceived of as a pessimistic belief about the returns to investment in one’s own physical appearance.

2.2 “Motivational” symptoms

The motivational symptoms of depression are mainly characterized by withdrawal from activities, escapist tendencies and avoidance of responsibility, the assumption

⁵Evidence on the predictors of depression onset suggests that shocks in domains where individuals believe outcomes are under their control are particularly predictive of depression (Kendler, Karkowski, and Prescott 1999).

of a child-like rather than an adult's role, and a focus on "immediate but transient gratification instead of delayed but prolonged gratifications". Specifically, Beck describes four symptoms in this category: First, patients have *paralysis of the will*, i.e. they "have a major problem in mobilizing themselves to perform even the most elemental and vital tasks". Beck identifies as the reason for this paralysis that "although they can define for themselves what they should do, they do not experience any internal stimulus to do it". Second, patients show *avoidance, escapist, and withdrawal wishes*: they want to shirk from their duties and want to withdraw into other activities. Third, patients exhibit increased *dependency* on others, in the sense that they want others to perform tasks for them. Finally, depressed patients often have *suicidal wishes*.

Most of these motivational symptoms can be understood as direct consequences of the core cognitive symptom described above, i.e. pessimistic beliefs about the returns to effort. In particular, when an individual believes that their actions lead to negative outcomes, she may naturally want others to perform tasks for them instead. Relatedly, if she believes that her own efforts will not amount to anything, so may choose not to undertake them in the first place, which presents itself as paralysis of the will to the observer. Similar reasoning could be implicated in avoidance, escapist, and withdrawal wishes, i.e. individuals with negative beliefs about the consequences of her actions may cause her to avoid having to perform these actions in the first place and instead withdraw from life. Finally, suicidal wishes may be an extreme manifestation of the escapist tendencies described above; for instance, they could occur when people believe that efforts generate *negative* returns.

2.3 "Emotional" symptoms

The emotional symptoms of depression mainly consist of dysphoria, i.e. low mood and an inability to feel pleasure, and related symptoms. Specifically, depressed patients experience *dejected mood*, i.e. they feel "sad", "hopeless", or "miserable". They also exhibit a *reduction in gratification*, in the sense that they are unable to derive pleasure from activities they usually enjoy. This inability extends to both professional and personal contexts, and includes basic activities such as eating and sex. Third, patients experience *negative feelings toward themselves*, blaming themselves for mistakes and believing that they "can't do anything right". Fourth, the inability to derive pleasure from previously enjoyable activities is accompanied by a *loss of emotional attachment*, i.e. a "decline in interest in particular activities or

in affection or concern for other persons,” including one’s job, family, and friends. Fourth, depressed patients show a *loss of the mirth response*, i.e. their sense of humor: they still understand the point of jokes, but do not find them funny. Finally, they frequently experience *crying spells*.

In terms of economic primitives, some of these symptoms can be understood as consequences of pessimistic beliefs about returns to effort. In particular, dejected mood and crying spells can be thought of as consequences of the reduction in income and overall experienced utility that results from pessimistic beliefs about the returns to effort (our model will make this effect explicit). Similarly, negative feelings toward oneself are a natural consequence of this effect to the extent one assumes blame (which depressed individuals often do; recall the “egocentric notions of causality” described above).

In contrast, loss of emotional attachment, reduction in gratification, and loss of mirth response are, in our view, best understood as consequences of a *low marginal utility of consumption of experiences, relationships, and humor*. This subgroup of emotional symptoms is the leading set of symptoms which is difficult to conceptualize as resulting from pessimistic beliefs about the returns to effort.⁶ Put differently, these symptoms appear to be about *preferences* rather than *beliefs*. In the present paper, we restrict ourselves to modeling depression as a change in beliefs, and leave it to others (including our future selves) to mangle the utility function.

2.4 Delusions

Depressed people frequently suffer from delusions of various types. Beck describes five main categories. First, in *delusions of worthlessness*, patients believe that they are such a burden to others that “it would be better if I had not been born”. Second, in delusions of *crime and punishment*, patients believe that they have committed crimes for which they “deserve to be punished”. In extreme cases, patients believe that they are the devil. In *nihilistic delusions*, patients believe that the world is “empty”, all other people have died, or they themselves have died. Other patients believe that some of their organs are missing. Relatedly, *somatic delusions* cause patients to believe their bodies are decaying or that they have fatal illnesses. Finally,

⁶It is tempting to think of these symptoms as pessimistic beliefs about investment in oneself and social relationships: depressed people may expect low “socio-emotional returns” when they invest in friendships or partnerships and when they engage in previously pleasurable activities. However, this view clashes with the fact that depressed people actually do fail to derive pleasure from these investments, instead of having pessimistic beliefs.

in *delusions of poverty*, patients believe that they are impoverished. Beck writes: “Delusions of poverty seem to be an outgrowth of the overconcern with finances manifested by depressed patients. A wealthy patient may complain bitterly, ‘All my money is gone. What will I live on? Who will buy food for my children?’”

Delusions are more difficult to fit into a framework of beliefs and preferences; for instance, the belief that one’s body is decaying or that organs are missing is not straightforward to explain. Nevertheless, several of the delusions described above are plausibly extreme consequences of pessimistic beliefs about returns to effort. Most prominently, the belief that one is or will be impoverished may be a natural consequence of such beliefs. Similarly, the belief that one is worthless, responsible for bad outcomes, and deserves punishment may be a consequence of the same type of belief.

2.5 Somatic symptoms

Not covered in Beck’s description of the symptoms of depression, but contained in the DSM-IV diagnosis criteria, are two important somatic symptoms. Specifically, depressed individuals often display either hypersomnia or insomnia, i.e. excessive sleeping or an inability to sleep. Secondly, they frequently suffer from either a lack of appetite, or overeating. These bi-directional effects of depression on eating and sleeping are more difficult to explain as a consequence of a simple change in beliefs about the returns to effort; however, as we illustrate formally in our model, it becomes straightforward when one considers that eating and sleeping have dual roles: on the one hand, they are consumption goods; on the other, they are inputs into production. We further assume that the optimum levels of food intake and sleep may be different for these two purposes: the consumption optimum may be higher or lower than the production optimum. In equilibrium, when both consumption and production motives matter, individuals will choose some intermediate level of eating or sleeping. When they develop pessimistic beliefs about their returns to effort, production motives become relatively less important, shifting the optimum level of eating or sleeping towards their “consumption” optima. As a consequence, the observed levels of eating and sleeping may either rise or fall, depending on whether the consumption optima lie below or above the production optima.

2.6 Hallucinations

Finally, depressed patients frequently report hallucinations. In the most common case, these consist of patients hearing voices “that condemn the patient”. Such hallucinations can possibly be understood as an extreme reaction to pessimism about oneself.

3 Stylized facts

In this section, we briefly present a number of empirical stylized facts about depression that our model attempts to predict. Owing to the dearth of good causal evidence on the consequences of depression, we mainly do this by presenting correlations between depression and other variables. We rely on the 2014–2015 wave of the Indonesia Family Life Survey (IFLS-5), which surveyed 50,148 individuals in 16,204 households. Depression is measured using the Center for Epidemiologic Studies Depression Scale (CESD), a widely used and validated self-report instrument for measuring depression. We emphasize that the usual disclaimers about correlational evidence apply, and that future work should tease out the direction and strength of causality in the relationships we describe below.

In our model, depression arises from negative shocks to an individual’s beliefs about the returns to effort, which in turn can be generated by negative economic shocks. We therefore begin by noting that in our data, economic shocks are associated with depression. We present in Table 1 the relationship between CESD scores and indicator variables for whether the household had a business that closed in the past 18 months, experienced natural disaster or civic strife, or experienced any economic disruption. We find moderately sized and highly significant associations between depression scores and all three variables, with the largest point estimate, a 0.19 standard deviations (SD) difference in depression scores, for households with a business that recently shut down.⁷ Thus, depression is associated with economic shocks. In addition, quasi-experimental evidence suggests that economic shocks in the form of floods, droughts, or job loss lead to increases in mental disorders, including depression (Amstadter et al. 2009; Goenjian et al. 2001; Mendolia 2009; see Rataj, Kunzweiler, and Garthus-Niegel 2016 for a review). Conversely, random-

⁷The fact that this point estimate is larger than the others also supports the claim that stressors over which an individual feels they have some control are more likely to precede depression (Kendler, Karkowski, and Prescott 1999).

ized controlled trials and natural experiments have shown that poverty alleviation interventions such as unconditional cash transfers lead to reductions in depression (Haushofer and Shapiro 2016). More broadly, programs like health insurance, pensions, microfinance, and access to water lead to improvements in overall mental health and psychological well-being (Devoto et al. 2012; Ssewamala, Han, and Neillands 2009; Ssewamala et al. 2012; Finkelstein et al. 2012; Rosero and Oosterbeek 2011; Tseng and Petrie 2012).

We next ask how depression relates to economic choice variables such as labor supply and expenditure decisions. Panels A–D of Figure I illustrate relevant relationships in the Indonesia data using local linear regressions. Our model predicts that labor supply should correlate negatively with depression, because pessimistic beliefs about returns to effort weaken the incentives to supply labor. Indeed, we find a strong negative overall relationship between depression and the number of hours the individual works in a typical week. The relationship is not completely monotonic at low levels of labor supply: below about 22 working hours per week, it has a shallow positive association with depression scores. However, over most of the distribution, the relationship is strongly negative.

Our model makes diverging predictions for investment and temptation goods. Because investment goods increase effective labor supply (e.g. by increasing human capital), we might expect them to be negatively correlated with depression; conversely, because temptation goods decrease effective labor supply (e.g. through negative health effects), we might expect them to be positively correlated with depression. Indeed, in the Indonesia data, we find negative relationships between depression and total expenditure, and spending on education; conversely, we find a positive relationship with spending on tobacco.⁸ This finding is supported by correlations between depression and changes in tobacco consumption within individuals (Taylor et al. 2014). The causal relationship between depression and tobacco use has been the subject of intense debate in the medical literature, with authors arguing both that smoking precedes and precipitates depression (Munafò et al. 2008; Boden, Fergusson, and Horwood 2010), and that depression increases smoking (Windle and Windle 2001); however, we are not aware of rigorously causally identified studies of the effect of changes in depression status on smoking.

We note that the medical literature largely mentions self-medication as the mo-

⁸Spending on another important temptation good, alcohol, is not shown because Indonesia is a Muslim country and therefore the vast majority of our sample do not consume any alcohol.

tivation for temptation good consumption in depression (Khantzian 1985). This is a stronger motive than what is implied by our model, which would predict an increase in temptation good consumption even in the absence of the need to self-medicate. Thus, the effects of depression on temptation good consumption predicted by our model may be lower bounds.

Finally, our model predicts non-monotonic relationships between depression and food intake, and between depression and sleep. These predictions are in accordance with the diagnosis criteria for depression, which suggest that depressed individuals suffer from either increased or decreased appetite, and sleeping “too much” or “too little”. In our data, we proxy increased or decreased food intake with body mass index (BMI, measured in kg/m^2), and sleep with the number of hours the individual slept in the preceding night. Panels E–F of Figure I show that indeed we find non-monotonic relationships between these variables and depression scores: high depression scores are associated with both very short and very long sleep duration, and with both high and low BMI. The upward-sloping relationship between BMI and depression at the upper end of the BMI distribution is not very pronounced, possibly because in this Indonesian sample, the BMI distribution does not have much support at high levels of BMI.

On the whole, we find good correlational support for the associations between depression and other variables that are predicted by our model. We stress again that these relationships are not causal, and can therefore only be suggestive. In particular, it is likely that in several cases, causality runs from the other variables to depression; e.g. being unable to work, being overweight or underweight, or having a sleep disorder can plausibly lead to depression. Future work should therefore test whether depression has a causal effect on any of these variables.

4 Model

Our theory sets up a simple decision-making problem in which the decision-maker’s beliefs about her ability, or the returns to her effort, play a central role. The central mechanism we highlight is a complementarity between the decision-maker’s belief about her ability and other important choices: effort provision, food consumption, sleep, investment and temptation good consumption. Negative shocks to the decision-maker’s beliefs about her ability alter her choices in these other domains accordingly. We begin by mapping out the behavioral responses to a change in

beliefs, then provide a Bayesian foundation for those changes.

We study a one-period model in which utility is quasi-linear in non-food consumption, c , food f and sleep s .

$$U(c, f, s) = c + \phi(f) + \psi(s) \tag{1}$$

We assume that ϕ and ψ are differentiable and concave, but not that they are everywhere increasing, instead we allow for a “bliss point” or utility-maximizing level of food and sleep consumption, f^C and s^C respectively, where $\phi'(f^C) = \psi'(s^C) = 0$.

The decision-maker’s income depends on her labor effort, as well as on her food and sleep choice. Food and sleep determine the number of effective labor units she supplies, according to the (for simplicity) separable function $\Phi(f) + \Psi(s)$. Once again we assume that Φ and Ψ are differentiable and concave, but not everywhere increasing. Eating too little or too much is bad for productivity (leading to poor health, morbidity and under- or over-weight, see e.g. Dasgupta and Ray 1986; Bliss and Stern 1978). Similarly sleeping too little or too much decreases productivity by creating fatigue or by decreasing the number of hours in the day available for work.⁹ The production-maximizing values are f^P and s^P defined by $\Phi'(f^P) = \Psi'(s^P) = 0$.

Effort is either high ($l = 1$) or low ($l = 0$). If she exerts low effort she receives a known, fixed return \bar{A} per effective labor unit. If she exerts high effort she receives a return A which we refer to as the “return to effort” or “ability”. The value of A is unknown and the decision-maker’s mean prior over A is μ .

We suggest two interpretations for the effort choice. The first is literally costly effort which is complementary to ability. Here, the return to low effort is safe and known but the decision-maker’s ability is unknown. Under this interpretation we assume that the cost of effort is measured per effective labor unit and that the returns \bar{A} and A are net of effort costs.¹⁰ The second is an occupational choice: low effort corresponds to a well-known or routine occupation (e.g. a low-wage routine job, subsistence farming or claiming unemployment support), while high effort corresponds to a more ambitious occupation with unknown returns that depend on ability.

Normalizing the units of f and c such that their relative prices are unity, the

⁹We might write the sleep function as $\tau(s) = \hat{\tau}(s)(24 - s)$ where $24 - s$ are total waking hours and $\hat{\tau}$ is an increasing concave function capturing the effect of sleep on per-hour output.

¹⁰While we could specify additive effort costs, our formulation greatly simplifies the analysis by reducing the effort decision to comparison of \bar{A} and μ , independent of f and s .

expected budget constraint when food and sleep choices are being made is:

$$c + f = (\mu l + \bar{A}(1 - l))(\Phi(f) + \Psi(s)) + \epsilon \quad (2)$$

where ϵ is an additive random income shock that is independent of the decision-maker's choices. ϵ captures shocks to disposable income that are beyond her control, such as exogenous unemployment, rainfall shocks and crop disease, losses due to crime, etc. The decision-maker only observes her choices l, f, s and total disposable income $(\mu l + \bar{A}(1 - l))(\Phi(f) + \Psi(s)) + \epsilon$, from which she can form an inference about A .¹¹

The production function is deliberately very basic – a simple product of ability, effort and effective labor supply. This enables us to highlight the role of the key complementarities with minimal additional complication. We conjecture that any reasonable production function that retains the basic complementarity between beliefs and choices, and any reasonable utility function that preserves the trade off between production and consumption motives will exhibit similar patterns of behavior.

Summarizing our functional form assumptions:

$$\begin{aligned} \phi'(0), \psi'(0), \Phi'(0), \Psi'(0) &> 0 \\ \phi'', \psi'', \Phi'', \Psi'' &< 0 \\ \phi'(f^C) = \psi'(s^C) = \Phi'(f^P) = \Psi'(s^P) &= 0 \end{aligned}$$

4.1 Depression

We identify depression with a negative shock to μ – the decision-maker's belief about her return to effort declines. For now, we leave the source of the shock unspecified, but we provide a simple Bayesian foundation below. Throughout the section we use Propositions to organize the findings, providing proofs when these are not already given in the text or immediate.

Conceptually, we distinguish between two types of shock. In the first case, where $\mu \geq A$, there is a “true” shock, in the sense that beliefs were previously too

¹¹It is not essential that the (perceived) distribution of ϵ is independent of l but we maintain that assumption for simplicity.

optimistic relative to the current value of A (possibly because A itself has decreased). In the second case, the shock is pessimistic, in the sense that $\mu < A$ and the decision-maker believes her return to effort is lower than it truly is. Both types of shock are important and relevant—not all depressed individuals are pessimistic. Genuine shocks to A which decrease expected future earnings, such as becoming unemployed, can cause the onset of depression without implying pessimism. Since A is unobserved, the behavioral implications of both kinds of shock are essentially identical.¹² However the two types of shock have different efficiency implications. Whenever $\mu \neq A$ choices will be suboptimal, but in the case of the pessimistic shock they can also lead to a poverty trap, as we illustrate below. Moreover, as we discuss below, while *expected* utility decreases in response to a decrease in μ , realized or “experienced” utility might actually increase if the shock brings μ closer to the true A .

4.2 Choices

To focus on the central insights of the model, we restrict attention to the case where the non-negativity constraint on c is not binding. The optimality conditions are as follows. For labor effort:

$$l^* = 1 \Leftrightarrow \mu > \bar{A} \tag{3}$$

This enables us to write the expression $\mu l^* + \bar{A}(1 - l^*)$ simply as $\max\{\mu, \bar{A}\}$. For food, sleep and non-food consumption we have:

$$\phi'(f^*) = 1 - \max\{\mu, \bar{A}\} \Phi'(f^*) \tag{4}$$

$$\psi'(s^*) = -\max\{\mu, \bar{A}\} \Psi'(s^*) \tag{5}$$

$$c^* + f^* = \max\{\mu, \bar{A}\} (\Phi(f^*) + \Psi(s^*)) + \epsilon \tag{6}$$

Because the decision-maker is risk-neutral over non-food consumption her food and sleep choices are fixed and all variation driven by ϵ or her forecast error about A is absorbed by non-food consumption.

¹²The key difference is in the sign of errors in forecasting disposable income, equal to $(A - \mu)l(\Phi(f) + \Psi(f))$. Quasi-linearity of utility implies that (provided non-negativity of c is not binding) this only affects non-food consumption, c which will be higher or lower than expected when $A - \mu \gtrless 0$.

Labor effort

From (3) we see that the decision-maker exerts high effort when she believes the high-effort technology to have a higher return than the low-effort technology. Thus there are states of the world where $A > \bar{A} > \mu$ such that she inefficiently chooses the low-effort technology. In other words, her depressed beliefs about A lead her to choose lower-return activities and decrease her income and consumption possibilities. We summarize the findings in the following Proposition:

Proposition 1. *Depression leads to a reduction in labor effort when it leads to $\bar{A} > \mu$. This is inefficient when $A > \bar{A}$.*

Food and sleep

From 4 and 5 we see that food and sleep choices reflect a tension between consumption and production motives. If only consumption motives mattered (for example, because $\mu = \bar{A} = 0$ or $\Phi', \Psi' = 0$), then food is chosen to equate its marginal utility to the opportunity cost (foregone non-food consumption through the budget constraint): $\phi'(f) = 1$, while sleep is chosen to maximize the utility of sleep, $\psi'(s) = 0$ (i.e. $s = s^C$). Alternatively, if only production motives matter ($\phi' = \psi' = 0$), food choice solves $\max\{\mu, \bar{A}\} \Phi'(f) = 1$ and sleep solves $\Psi'(s) = 0$ (i.e. $s = s^P$). When both consumption and productive motives matter, they solve $\phi'(f) + \max\{\mu, \bar{A}\} \Phi'(f) = 1$ and $\psi'(s^*) + \max\{\mu, \bar{A}\} \Psi'(s^*) = 0$ and we observe that some decision-makers will eat or sleep more than maximizes production, and others will eat or sleep less.

Remark 1. We refer to over- and under-eating and sleeping relative to the production-maximizing benchmark, rather than a utility benchmark. First, because we feel it is easier and less controversial to read the symptomatology of depression in terms of changes in functioning capacity than utility (in the sense that “she would be better off if she ate more/less”). Second, because the changes in eating and sleeping behavior induced by depression are caused by movement away from the production optimum due to a decrease in the importance of production motives.

Remark 2. Denote the solutions to $\phi'(f) = 1$ and $\max\{\mu, \bar{A}\} \Phi'(f) = 1$ by f^{C*} and f^{P*} respectively. Then $f^* \in [\min\{f^{C*}, f^P\}, \max\{f^{C*}, f^P\}]$.

Proof. From the first-order condition, $\phi'(f) + \max\{\mu, \bar{A}\} \Phi'(f) = 1$. Call the left-hand side expression $F(f)$ and observe that $F'(f) < 0$. Note also that $f^{C*} < f^C$

and $f^{P*} < f^P$. Suppose $f^{C*} < f^P$. Then $F(f^{C*}) = 1 + \max\{\mu, \bar{A}\} \Phi'(f^{C*}) > 1$, and $F(f^P) = \phi'(f^P) + 0 < 1$. Hence $f^* \in [f^{C*}, f^P]$. Suppose $f^P < f^{C*}$. Then $F(f^P) = \phi'(f^P) + 0 > 1$, and $F(f^{C*}) = 1 + \max\{\mu, \bar{A}\} \Phi'(f^{C*}) < 1$. Hence $f^* \in [f^P, f^{C*}]$. Finally, if $f^{C*} = f^P$ then $f^* = f^{C*} = f^P$. \square

Remark 3. $s^* \in [\min\{s^C, s^P\}, \max\{s^C, s^P\}]$.

Proof. From the first-order condition, $\psi'(s^*) + \max\{\mu, \bar{A}\} \Psi'(s^*) = 0$. Call the left-hand side expression $S(s)$ and observe that $S'(s) < 0$. Suppose $s^C < s^P$. Then $S(s^C) = 0 + \max\{\mu, \bar{A}\} \Psi'(s^C) > 0$, and $S(s^P) = \psi(s^P) + 0 < 0$. Hence $s^* \in [s^C, s^P]$. Suppose if $s^P < s^C$. Then $S(s^P) = \psi(s^P) + 0 > 0$ and $S(s^C) = 0 + \max\{\mu, \bar{A}\} \Psi'(s^C) < 0$. Hence $s^* \in [s^P, s^C]$. Finally, if $s^C = s^P$ then $s^* = s^C = s^P$. \square

Remark 4. The qualitative difference between the sleep and food optima is that the cost of sleep in the budget constraint is foregone production, and therefore incorporated into the production-maximizing choice s^P and irrelevant to the utility-maximizing choice. The cost of food in the budget constraint is income that would otherwise have been spent on non-food consumption, and therefore not factored into the utility- or production-maximizing food choices (f^C or f^P).

What then happens to food and sleep consumption when μ decreases? Intuitively it is straightforward to see that there will be a substitution effect: behavior will drift toward what might be called the decision-maker's "natural tendency" – to eat and sleep as if production motives were not important. By quasi-linearity (and the assumption that $c > 0$) there is no income effect on food and sleep.

Proposition 2. *For each of food and sleep, a decision-maker who is initially consuming more than her production optimum will increase consumption when she becomes depressed (i.e. when μ decreases), while if she is initially consuming less than her production optimum she will decrease consumption when she becomes depressed.*

Proof. When $\mu > \bar{A}$, differentiating the first-order conditions, we obtain:

$$\begin{aligned} \frac{df^*}{d\mu} &= -\frac{\Phi'(f^*)}{\phi''(f^*) + \mu\Phi''(f^*)} \leq 0 \Leftrightarrow f^* \geq f^P \\ \frac{ds^*}{d\mu} &= -\frac{\Psi'(s^*)}{\psi''(s^*) + \mu\Psi''(s^*)} \leq 0 \Leftrightarrow s^* \geq s^P \end{aligned}$$

If $\mu \leq \bar{A}$ food and sleep do not depend on μ . Note that we associate depression with a *decrease* in μ so the sign of the effect of becoming depressed is the opposite of the sign of $\frac{d}{d\mu}$. \square

Total expenditure and non-food consumption

A decrease in μ decreases income in two ways. First, it may lead to the decision-maker wrongly believing low effort is optimal ($A > \bar{A} > \mu$) in which case she inefficiently chooses low effort. Second, it decreases effective labor supply since as shown above a decrease in μ causes food consumption and sleep to move away from their production-maximizing values. Holding the realized ϵ fixed and starting from a value $\mu > \bar{A}$ we have:

$$\begin{aligned} \frac{d}{d\mu} (\Phi(f^*) + \Psi(s^*)) &= \Phi'(f^*) \frac{df^*}{d\mu} + \Psi'(s^*(\mu)) \frac{ds^*}{d\mu} \\ &= -\frac{\Phi'(f^*)^2}{\phi''(f^*) + \mu\Phi''(f^*)} - \frac{\Psi'(s^*)^2}{\psi''(s^*) + \mu\Psi''(s^*)} \\ &> 0 \end{aligned}$$

Since all income is consumed, the effect on total consumption $c + f$ is unambiguously negative. Because of our quasi-linearity assumption only non-food consumption responds directly to the decrease in income, absorbing all income not spent on food. However, since food consumption may also decrease as shown above, the total effect on non-food consumption is ambiguous. From a starting point $\mu > \bar{A}$ the effect on *realized* non-food consumption (note that this depends on the true A and not the belief μ) is:

$$\begin{aligned} \frac{dc^*}{d\mu} &= -\frac{df^*}{d\mu} + A \frac{d}{d\mu} (\Phi(f^*) + \Psi(s^*)) \\ &= -\underbrace{\frac{(A\Phi'(f^*) - 1)\Phi'(f^*)}{\phi''(f^*) + \mu\Phi''(f^*)}}_{\geq 0} - \underbrace{\frac{\Psi'(s^*)^2}{\psi''(s^*) + \mu\Psi''(s^*)}}_{\leq 0} \end{aligned}$$

The second term, which captures the contribution of sleep changes, is unambiguously negative (meaning that c decreases when μ decreases), because a decrease in μ causes sleeping patterns to deviate further from the production-maximizing s^P , leading to a fall in income and non-food consumption.

The sign of the first term, the contribution of food consumption, is ambiguous because food appears both in the production function and the budget constraint. If $\Phi'(f^*) < 0$ (i.e. $f^* > f^P$), depression decreases non-food consumption because this is the case where initially the consumer was “over-eating”, and becoming depressed induces her to eat more. Increased food expenditure and lower overall income feed into lower non-food consumption. If $A\Phi'(f^*) > 1$ (i.e. $f^* < f^{P*}$), food consumption decreases but the fall in income more exceeds the decrease in expenditure on food, leading to a decrease in non-food consumption. When $0 < A\Phi'(f^*) < 1$, (i.e. when $f^* \in (f^{P*}, f^P)$) food consumption falls but this actually brings the consumer closer to f^{P*} , the value of food consumption that maximizes income net of food expenditure. Therefore more income is left to be spent on non-food consumption.

Proposition 3. *When the decision-maker becomes depressed, total consumption expenditure falls. The effect on non-food consumption is ambiguous, depending on the net effect of the contribution of food and sleep to effective labor supply and expenditure on food. Non-food consumption unambiguously decreases when $A\Phi'(f^*) \geq 1$ or $A\Phi'(f^*) \leq 0$.*

Expected utility

A decrease in μ leads to a fall in expected utility by a standard Envelope Theorem argument, since it decreases expected income in every state of the world. The effect on realized or “experienced” utility depends on whether the decision-maker’s belief μ is pessimistic ($\mu < A$) or optimistic ($\mu > A$) (recall that we define depression as a decrease in μ , which is not necessarily pessimistic). Experienced utility is maximized when beliefs are correct, $\mu = A$, so a shock that makes the decision-maker less optimistic actually improves the quality of her decision-making.

Temptation and investment goods

Two other important classes of decision are also plausibly complementary with beliefs about the return to effort, which we will refer to as investment and temptation goods. Investment goods e (such as education) are costly but increase effective labor supply, while temptation goods t (such as alcohol) are pleasurable but decrease effective labor supply. Standard treatments of temptation goods such as the quasi-hyperbolic model (Laibson 1997) or models of self-control (Gul and Pesendorfer 2001; Fudenberg and Levine 2006) emphasize the trade off between present benefits

and future costs, or an internal conflict between temptation and self control. Here we focus on the tradeoff between production and consumption motives.

We extend the utility function and budget constraint as follows:

$$\begin{aligned} U(c, f, s, t) &= c + \phi(f) + \psi(s) + \omega(t) \\ c + f + e + t &= (\mu l + \bar{A}(1 - l))(\Phi(f) + \Psi(s) + \Sigma(e) + \Omega(t)) + \epsilon \end{aligned}$$

Investment goods appear only in the budget constraint. We normalize the price of e to unity, and assume that production is increasing in e via Σ , where $\Sigma' > 0$, $\Sigma'' < 0$. The decision-maker invests until the marginal cost equals the marginal benefit, solving the first-order condition:

$$1 = \max \{ \mu, \bar{A} \} \Sigma'(e^*)$$

Temptation goods appear in the utility function via ω . We assume $\omega'(0) > 0$, $\omega'' < 0$ and ω may be strictly increasing or have a bliss point, $\omega(t^C)$ (drinking alcohol is only pleasurable up to a point). However temptation goods must be purchased (again we normalize the price to unity) and have a deleterious effect on production, either by their immediate effects on effective labor supply (e.g. alcohol consumption impairs cognition) or via negative health impacts. This is captured by $\Omega(t)$, $\Omega' < 0$, $\Omega'' > 0$. The decision-maker trades off the utility benefits of t consumption with the cost via reduced income and increased expenditure, the first-order condition is:

$$\omega'(t^*) = 1 - \max \{ \mu, \bar{A} \} \Omega'(t^*)$$

We immediately see (as is obvious from the logic of complementarity) that $\frac{dt^*}{d\mu} \leq 0$ and $\frac{de^*}{d\mu} \geq 0$ (both strict when $\mu > \bar{A}$). By decreasing the importance of production motives, a fall in μ leads the decision-maker to spend less on investments in herself or her own productivity, and more on temptation goods that harm her health and productivity.

The same logic naturally carries over to a dynamic framework in which the cost of the temptation good arises in the future. Take smoking, for example. Smoking has two relevant effects, it shortens life expectancy and increases the likelihood of productivity-decreasing health problems during life. If the decision-maker believes her productivity to be permanently lower than before then the cost of both effects

decreases, leading her to smoke more in the present.

Proposition 4. *Depression leads to an increase in temptation good consumption, and a decrease in investment good expenditure.*

4.3 Foundation of beliefs

In this section we provide a simple Bayesian foundation for the belief μ . While there is surely a role for imperfect Bayesian updating – indeed we suspect that a fully Bayesian model would have quantitative difficulty generating the kinds of persistent pessimistic beliefs and withdrawal associated with depression – the Bayesian model is sufficient to give the key intuitions.

We make three basic points. First, shocks to income via ϵ , such as becoming unemployed, will be partially attributed to A , leading to decreases in μ and depression. Second, the decision-maker’s beliefs about where shocks come from matter – if she expects that income variation is mostly driven by forces outside her control she will not infer much about μ when she experiences a negative income shock, in accordance with empirical evidence on the types of shocks that cause people to become depressed. Third, persistent depression can arise when the decision-maker experiences a shock that causes her to withdraw her effort and therefore stop learning about A .¹³

Consider the simplest possible dynamic version of our model, in which static decisions are made over time. The only link between periods is via beliefs, specifically μ which may evolve over time as the decision-maker learns, and we assume that actions are chosen to maximize the current period’s utility. In a richer model the decision-maker might make forward-looking decisions, for instance saving for the future or investing in human capital, and learning motives might influence her actions (e.g. she exerts effort even though she believes the returns are low, so as to learn about A). While interesting, allowing for these behaviors greatly increases complexity without (we conjecture) many new insights.

We assume that A is a fixed but unknown parameter.¹⁴

The decision-maker believes that $\epsilon \sim N(0, \sigma_\epsilon^2)$. She begins period $t - 1$ with the

¹³In a similar vein, in Piketty (1995), decision-makers can reach different conclusions about the returns to effort and importance of redistribution.

¹⁴It is straightforward to extend the analysis to the more realistic case where A is a random walk and the decision-maker wants to infer the current level of A .

following belief about A :

$$A \sim N(\mu_{t-1}, \sigma_{A,t-1}^2)$$

Her income realization is:

$$y_{t-1} = (Al_{t-1} + \bar{A}(1 - l_{t-1}))H_{t-1} + \epsilon_{t-1}$$

where $H_{t-1} = \Phi(f_{t-1}) + \Psi(s_{t-1})$ is her effective labor supply in $t-1$. If she exerted low effort $l_{t-1} = 0$ she does not receive any information about A so her posterior μ_t equals her prior. If she exerts high effort, we can write y_{t-1} as:

$$y_{t-1} = x_{t-1} + \epsilon_{t-1}$$

where $x_{t-1} = AH_{t-1} \sim N(\mu_{t-1}H_{t-1}, \sigma_{A,t-1}^2 H_{t-1}^2)$. Then, the standard signal extraction result is:

$$\begin{aligned} E(x_{t-1}|y_{t-1}) &= E(x_{t-1}) + \frac{\text{Var}(x_{t-1})}{\text{Var}(x_{t-1}) + \sigma_\epsilon^2} (y_{t-1} - E(x_{t-1})) \\ &= \mu_{t-1}H_{t-1} + \frac{\sigma_{A,t-1}^2}{\sigma_{A,t-1}^2 + \frac{\sigma_\epsilon^2}{H_{t-1}^2}} ((A - \mu_{t-1})H_{t-1} + \epsilon_{t-1}) \end{aligned}$$

and hence the posterior is:

$$\mu_t = \mu_{t-1} + \frac{\sigma_{A,t-1}^2}{\sigma_{A,t-1}^2 + \frac{\sigma_\epsilon^2}{H_{t-1}^2}} \left(A - \mu_{t-1} + \frac{\epsilon_{t-1}}{H_{t-1}} \right) \quad (7)$$

We make three observations. First, in our literature discussion we have emphasized the strong causal link from shocks to depression. In the model, negative ϵ shocks to y lead the decision-maker to infer that her productivity is lower than she previously thought, i.e. to decrease μ .

Second, there is some evidence that depression is particularly associated with stressors over which the individual believes they have control (Kendler, Karkowski, and Prescott 1999). In the model, such cases are captured by a belief that σ_ϵ^2 is small relative to σ_A^2 (i.e. I am confident that exogenous influences on my income are small), in which case beliefs are highly susceptible to pessimism following a large negative outcome.

For example, take the limit case $\sigma_\epsilon^2 \rightarrow 0$ with correct prior ($\mu_{t-1} = A$). Then, after a surprise shock ϵ_{t-1} , the change in beliefs is $\mu_t - \mu_{t-1} = \frac{\epsilon_{t-1}}{H_{t-1}}$, i.e. the entire shock is attributed to productivity A .¹⁵

However, one consequence of a decline in μ is that the decision-maker withdraws labor effort $l = 0$, in which case she ceases learning about A and finds herself in a poverty trap (see below). Additionally she also chooses a lower level of H which decreases the signal-to-noise ratio and slows down learning. In the limit as $H \rightarrow 0$, $E(\mu_t - \mu_{t-1} | A, t-1) \rightarrow 0$ as well. In other words reductions in labor supply, holding the the shock variance σ_ϵ^2 constant, slow down the speed of learning.

4.3.1 Poverty traps

If the shock to μ is such that the decision-maker continues to exert high effort, though at a less-optimal level of food and sleep, then she can be expected to learn the true value of A over time. However, more interesting is the case in which the shock is sufficiently large that she chooses to exert low effort. At this point she ceases learning about A and finds herself in a depression poverty trap with low income and consumption and persistently depressed beliefs about the return to her effort.

In the dynamic model sketched above, the decision-maker does not consider the expected learning value of continuing to exert high effort. Adding this feature would lead the decision-maker to sometimes exert effort when $\mu < \bar{A}$, because of the option value of experimentation – she knows that there is some chance the true A is greater than \bar{A} . Nevertheless she will still cease experimenting when μ is sufficiently low. A paper with a closely related intuition is Ali (2011), in which the decision-maker learns about her own temptations over time, and can choose to impose self-control (restrict choice) at the cost of impeding the learning process (because she can no longer give in to temptation). As a result, she may never fully learn, leading to overregulation of choice (the analog of our under-provision of effort).¹⁶

In our model there are only two levels of effort, for simplicity. A richer model would allow the decision-maker to reduce but not completely withdraw her effort. Such effort reduction, which can be thought of as a decrease in H , decreases the

¹⁵Given such beliefs, if l and H remain constant, beliefs converge rapidly back to the truth after a shock: $E(\mu_t - \mu_{t-1} | A, t-1) = \frac{\sigma_{A,t-1}^2}{\sigma_{A,t-1}^2 + \frac{\sigma_\epsilon^2}{H_{t-1}^2}} (A - \mu_{t-1}) \xrightarrow{\sigma_\epsilon^2 \rightarrow 0} A - \mu_{t-1}$.

¹⁶Relatedly, Veldkamp (2005) and Van Nieuwerburgh and Veldkamp (2006) study business-cycle models in which production cutbacks in recession impede learning about recovery, leading to slower booms than busts.

signal to noise ratio and so slows but does not completely stop learning – the decision-maker would eventually learn the true value of A .

4.3.2 Learned helplessness

A closely related phenomenon in psychology and psychiatry is that of learned helplessness: when experimental animals such as rats are exposed to electric shocks, they are typically motivated to avoid such shocks and will engage in exploratory behavior to do so. However, after repeated exposure to extremely strong shocks, the animals stop exploring and instead display a freezing response, known as “learned helplessness”. The prominent psychologist Martin Seligman considers learned helplessness one of the main underlying mechanisms in depression (Maier and Seligman 1976), and it has obvious similarity with the poverty trap scenario described here.

5 Conclusion

Here we briefly summarize the findings from the theoretical exercise. We show that when the decision-maker adopts a pessimistic view of the returns to her labor effort, she becomes more likely to “withdraw”, exerting low labor effort and choosing the subsistence, safe, low return activity or occupation. As a consequence of decreased labor supply, total expenditure (food plus non-food consumption) decreases.¹⁷ Food and sleep consumption may increase or decrease: over-eaters/sleepers (relative to the gross income maximizing choice) increase their food and sleep, while under-eaters/sleepers decrease their food and sleep. Consistent with empirical evidence on the behavior of depressed patients, investment good expenditure decreases, and temptation good expenditure increases.

Together, our simple model speaks to several of the core symptoms of depression; in particular, our framework predicts well what Beck termed “cognitive” and “motivational” symptoms of depression, i.e. pessimistic beliefs about oneself, the world, and the future, and an inability or unwillingness to perform daily tasks and make decisions. Some of the emotional symptoms of depression, such as depressed mood, follow naturally from these cognitive and motivational consequences. The exception is a subset of emotional symptoms, such as dysphoria and loss of the mirth response

¹⁷Non-food consumption may increase or decrease. In general it decreases for people already eating more than maximizes gross income, and for people already eating less than maximizes net income from food, but may increase for intermediate cases.

and social attachments, which are better understood as low marginal utility from pleasurable activities.

In addition, our model can generate a poverty trap: when a negative shock makes an individual sufficiently pessimistic about the returns to her effort, she optimally chooses not to exert any effort at all. As a result, she does not learn about her true returns to effort, and finds herself in a depression-induced poverty trap.

Finally, our model can be tested empirically. In particular, the hypothesized effects of depression on eating and sleeping patterns make sharp predictions: we would predict that people who sleep or eat less than their productive optimum would become more extreme in this behavior when they become depressed; conversely for those who sleep or eat more than their productive optimum. A challenge for empirical work is to estimate the output-maximizing levels of food and sleep for different individuals; however, a first step might be made by making the simplifying assumption that extremely underweight or extreme overweight individuals are below and above their productive optima, respectively.

Our main goal in writing this paper was to give economists a starting point for thinking and writing about depression using the language of economics. We have therefore kept the model as simple as possible. We have also steered clear of modifying the utility function; future work might attempt to describe that subset of the emotional symptoms of depression we do not model here by taking this approach. Together, our hope is that this approach will enable economists to advance our understanding of depression in particular, and mental health in general.

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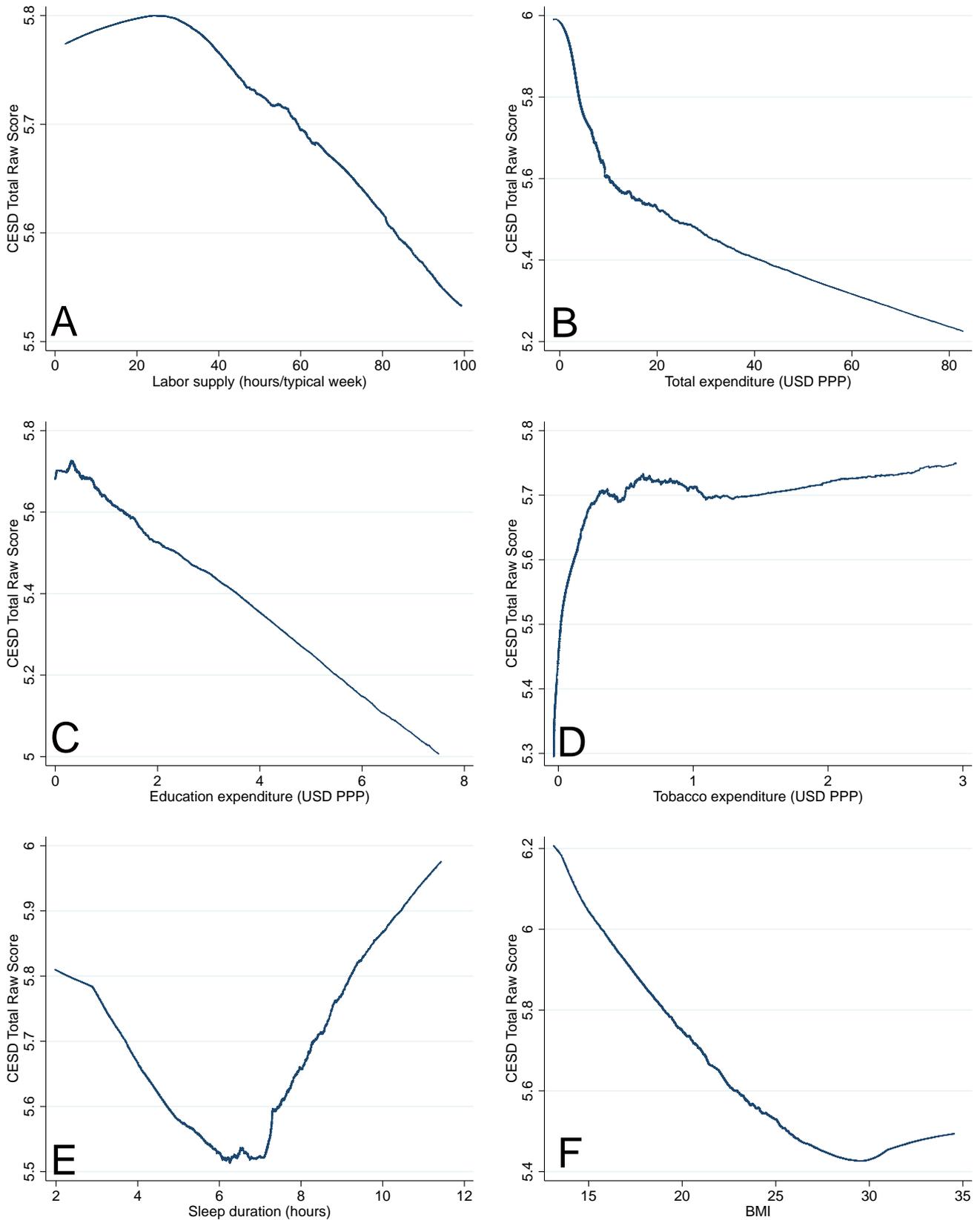
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Figure I: Relationship between depression and other variables



Notes: Local linear regressions of depression (CESD) scores on other variables. The raw CESD score ranges from 0 (not depressed) to 60 (severely depressed), with a cutoff of 16 for depression. Labor supply is measured in hours of labor supplied by the respondent in their main income-generating activity in a typical week; we exclude individuals who supplied zero or more than 100 hours of labor. Total expenditure and spending on tobacco and education is measured in USD PPP. Sleep duration is measured through self-report in hours for the preceding night. BMI is imputed from self-reports of height and weight. In each regression we first use the Frisch-Waugh theorem to create residuals from a regression of the variables of interest on gender, age, their square terms, and the interactions; we then create a new variable by adding the unconditional mean. Local linear regressions use a tricube weighting function and have a bandwidth of 0.8.

Table 1: CESD Correlations: Economic Variables

	(1) CESD Total Raw Score	(2) CESD Total Z-Score	(3) N
HH Business shut down in last 18 months	0.8077*** (0.2367)	0.1902*** (0.0557)	13095
Experienced natural disaster or civil strife	0.3967*** (0.0695)	0.0934*** (0.0164)	31401
Experienced economic disruption	0.5800*** (0.0703)	0.1366*** (0.0166)	31401

Notes: Each row is a separate regression of depression on the variable listed on the left. Each regression includes controls for sex and age. Standard errors are clustered at the household level and are reported in parenthesis below the coefficient estimate. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level.

Appendix

A Major Depressive Disorder: DSM-5 Diagnostic Criteria

- A. Five (or more) of the following symptoms have been present during the same 2-week period and represent a change from previous functioning: at least one of the symptoms is either (1) depressed mood or (2) loss of interest or pleasure. **Note:** Do not include symptoms that are clearly attributable to another medical condition.
- (a) Depressed mood most of the day, nearly every day, as indicated by either subjective report (e.g., feels sad, empty, hopeless) or observation made by others (e.g., appears tearful). (**Note:** In children and adolescents, can be irritable mood.)
 - (b) Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day (as indicated by either subjective account or observation).
 - (c) Significant weight loss when not dieting or weight gain (e.g., a change of more than 5% of body weight in a month), or decrease or increase in appetite nearly every day. (**Note:** In children, consider failure to make expected weight gain.)
 - (d) Insomnia or hypersomnia nearly every day.
 - (e) Psychomotor agitation or retardation nearly every day (observable by others, not merely subjective feelings of restlessness or being slowed down).
 - (f) Fatigue or loss of energy nearly every day.
 - (g) Feelings of worthlessness or excessive or inappropriate guilt (which may be delusional) nearly every day (not merely self-reproach or guilt about being sick).
 - (h) Diminished ability to think or concentrate, or indecisiveness, nearly every day (either by subjective account or as observed by others).
 - (i) Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan

for committing suicide.

- B. The symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.
- C. The episode is not attributable to the physiological effects of a substance or to another medical condition.

Note: Criteria A–C represent a major depressive episode.

Note: Responses to a significant loss (e.g., bereavement, financial ruin, losses from a natural disaster, a serious medical illness or disability) may include the feelings of intense sadness, rumination about the loss, insomnia, poor appetite, and weight loss noted in Criterion A, which may resemble a depressive episode. Although such symptoms may be understandable or considered appropriate to the loss, the presence of a major depressive episode in addition to the normal response to a significant loss should also be carefully considered. This decision inevitably requires the exercise of clinical judgment based on the individual's history and the cultural norms for the expression of distress in the context of loss.¹⁸

- D. The occurrence of the major depressive episode is not better explained by schizoaffective disorder, schizophrenia, schizophreniform disorder, delusional disorder, or other specified and unspecified schizophrenia spectrum and other psychotic disorders.

¹⁸In distinguishing grief from a major depressive episode (MDE), it is useful to consider that in grief the predominant affect is feelings of emptiness and loss, while in MDE it is persistent depressed mood and the inability to anticipate happiness or pleasure. The dysphoria in grief is likely to decrease in intensity over days to weeks and occurs in waves, the so-called pangs of grief. These waves tend to be associated with thoughts or reminders of the deceased. The depressed mood of MDE is more persistent and not tied to specific thoughts or preoccupations. The pain of grief may be accompanied by positive emotions and humor that are uncharacteristic of the pervasive unhappiness and misery characteristic of MDE. The thought content associated with grief generally features a preoccupation with thoughts and memories of the deceased, rather than the self-critical or pessimistic ruminations seen in MDE. In grief, self-esteem is generally preserved, whereas in MDE feelings of worthlessness and self-loathing are common. If self-derogatory ideation is present in grief, it typically involves perceived failings vis-à-vis the deceased (e.g., not visiting frequently enough, not telling the deceased how much he or she was loved). If a bereaved individual thinks about death and dying, such thoughts are generally focused on the deceased and possibly about "joining" the deceased, whereas in MDE such thoughts are focused on ending one's own life because of feeling worthless, undeserving of life, or unable to cope with the pain of depression.

E. There has never been a manic episode or a hypomanic episode.

Note: This exclusion does not apply if all of the manic-like or hypomanic-like episodes are substance-induced or are attributable to the physiological effects of another medical condition.

Diagnostic Features

The criterion symptoms for major depressive disorder must be present nearly every day to be considered present, with the exception of weight change and suicidal ideation. Depressed mood must be present for most of the day, in addition to being present nearly every day. Often insomnia or fatigue is the presenting complaint, and failure to probe for accompanying depressive symptoms will result in underdiagnosis. Sadness may be denied at first but may be elicited through interview or inferred from facial expression and demeanor. With individuals who focus on a somatic complaint, clinicians should determine whether the distress from that complaint is associated with specific depressive symptoms. Fatigue and sleep disturbance are present in a high proportion of cases; psychomotor disturbances are much less common but are indicative of greater overall severity, as is the presence of delusional or near-delusional guilt.

The essential feature of a major depressive episode is a period of at least 2 weeks during which there is either depressed mood or the loss of interest or pleasure in nearly all activities (Criterion A). In children and adolescents, the mood may be irritable rather than sad. The individual must also experience at least four additional symptoms drawn from a list that includes changes in appetite or weight, sleep, and psychomotor activity; decreased energy; feelings of worthlessness or guilt; difficulty thinking, concentrating, or making decisions; or recurrent thoughts of death or suicidal ideation or suicide plans or attempts. To count toward a major depressive episode, a symptom must either be newly present or must have clearly worsened compared with the person's pre-episode status. The symptoms must persist for most of the day, nearly every day, for at least 2 consecutive weeks. The episode must be accompanied by clinically significant distress or impairment in social, occupational, or other important areas of functioning. For some individuals with milder episodes, functioning may appear to be normal but requires markedly increased effort.

The mood in a major depressive episode is often described by the person as depressed, sad, hopeless, discouraged, or "down in the dumps" (Criterion A1). In some cases, sadness may be denied at first but may subsequently be elicited by

interview (e.g., by pointing out that the individual looks as if he or she is about to cry). In some individuals who complain of feeling "blah," having no feelings, or feeling anxious, the presence of a depressed mood can be inferred from the person's facial expression and demeanor. Some individuals emphasize somatic complaints (e.g., bodily aches and pains) rather than reporting feelings of sadness. Many individuals report or exhibit increased irritability (e.g., persistent anger, a tendency to respond to events with angry outbursts or blaming others, an exaggerated sense of frustration over minor matters). In children and adolescents, an irritable or cranky mood may develop rather than a sad or dejected mood. This presentation should be differentiated from a pattern of irritability when frustrated.

Loss of interest or pleasure is nearly always present, at least to some degree. Individuals may report feeling less interested in hobbies, "not caring anymore," or not feeling any enjoyment in activities that were previously considered pleasurable (Criterion A2). Family members often notice social withdrawal or neglect of pleasurable avocations (e.g., a formerly avid golfer no longer plays, a child who used to enjoy soccer finds excuses not to practice). In some individuals, there is a significant reduction from previous levels of sexual interest or desire.

Appetite change may involve either a reduction or increase. Some depressed individuals report that they have to force themselves to eat. Others may eat more and may crave specific foods (e.g., sweets or other carbohydrates). When appetite changes are severe (in either direction), there may be a significant loss or gain in weight, or, in children, a failure to make expected weight gains may be noted (Criterion A3).

Sleep disturbance may take the form of either difficulty sleeping or sleeping excessively (Criterion A4). When insomnia is present, it typically takes the form of middle insomnia (i.e., waking up during the night and then having difficulty returning to sleep) or terminal insomnia (i.e., waking too early and being unable to return to sleep). Initial insomnia (i.e., difficulty falling asleep) may also occur. Individuals who present with oversleeping (hypersomnia) may experience prolonged sleep episodes at night or increased daytime sleep. Sometimes the reason that the individual seeks treatment is for the disturbed sleep.

Psychomotor changes include agitation (e.g., the inability to sit still, pacing, handwringing; or pulling or rubbing of the skin, clothing, or other objects) or retardation (e.g., slowed speech, thinking, and body movements; increased pauses before answering; speech that is decreased in volume, inflection, amount, or variety of con-

tent, or muteness) (Criterion A5). The psychomotor agitation or retardation must be severe enough to be observable by others and not represent merely subjective feelings.

Decreased energy, tiredness, and fatigue are common (Criterion A6). A person may report sustained fatigue without physical exertion. Even the smallest tasks seem to require substantial effort. The efficiency with which tasks are accomplished may be reduced. For example, an individual may complain that washing and dressing in the morning are exhausting and take twice as long as usual.

The sense of worthlessness or guilt associated with a major depressive episode may include unrealistic negative evaluations of one's worth or guilty preoccupations or ruminations over minor past failings (Criterion A7). Such individuals often misinterpret neutral or trivial day-to-day events as evidence of personal defects and have an exaggerated sense of responsibility for untoward events. The sense of worthlessness or guilt may be of delusional proportions (e.g., an individual who is convinced that he or she is personally responsible for world poverty). Blaming oneself for being sick and for failing to meet occupational or interpersonal responsibilities as a result of the depression is very common and, unless delusional, is not considered sufficient to meet this criterion.

Many individuals report impaired ability to think, concentrate, or make even minor decisions (Criterion A8). They may appear easily distracted or complain of memory difficulties. Those engaged in cognitively demanding pursuits are often unable to function. In children, a precipitous drop in grades may reflect poor concentration. In elderly individuals, memory difficulties may be the chief complaint and may be mistaken for early signs of a dementia ("pseudodementia"). When the major depressive episode is successfully treated, the memory problems often fully abate. However, in some individuals, particularly elderly persons, a major depressive episode may sometimes be the initial presentation of an irreversible dementia.

Thoughts of death, suicidal ideation, or suicide attempts (Criterion A9) are common. They may range from a passive wish not to awaken in the morning or a belief that others would be better off if the individual were dead, to transient but recurrent thoughts of committing suicide, to a specific suicide plan. More severely suicidal individuals may have put their affairs in order (e.g., updated wills, settled debts), acquired needed materials (e.g., a rope or a gun), and chosen a location and time to accomplish the suicide. Motivations for suicide may include a desire to give up in the face of perceived insurmountable obstacles, an intense wish to end

what is perceived as an unending and excruciatingly painful emotional state, an inability to foresee any enjoyment in life, or the wish to not be a burden to others. The resolution of such thinking may be a more meaningful measure of diminished suicide risk than denial of further plans for suicide.

The evaluation of the symptoms of a major depressive episode is especially difficult when they occur in an individual who also has a general medical condition (e.g., cancer, stroke, myocardial infarction, diabetes, pregnancy). Some of the criterion signs and symptoms of a major depressive episode are identical to those of general medical conditions (e.g., weight loss with untreated diabetes; fatigue with cancer; hypersomnia early in pregnancy; insomnia later in pregnancy or the postpartum). Such symptoms count toward a major depressive diagnosis except when they are clearly and fully attributable to a general medical condition. Nonvegetative symptoms of dysphoria, anhedonia, guilt or worthlessness, impaired concentration or indecision, and suicidal thoughts should be assessed with particular care in such cases. Definitions of major depressive episodes that have been modified to include only these nonvegetative symptoms appear to identify nearly the same individuals as do the full criteria.

Associated Features Supporting Diagnosis

Major depressive disorder is associated with high mortality, much of which is accounted for by suicide; however, it is not the only cause. For example, depressed individuals admitted to nursing homes have a markedly increased likelihood of death in the first year. Individuals frequently present with tearfulness, irritability, brooding, obsessive rumination, anxiety, phobias, excessive worry over physical health, and complaints of pain (e.g., headaches; joint, abdominal, or other pains). In children, separation anxiety may occur.

Although an extensive literature exists describing neuroanatomical, neuroendocrinological, and neurophysiological correlates of major depressive disorder, no laboratory test has yielded results of sufficient sensitivity and specificity to be used as a diagnostic tool for this disorder. Until recently, hypothalamic-pituitary-adrenal axis hyperactivity had been the most extensively investigated abnormality associated with major depressive episodes, and it appears to be associated with melancholia, psychotic features, and risks for eventual suicide. Molecular studies have also implicated peripheral factors, including genetic variants in neurotrophic factors and pro-inflammatory cytokines. Additionally, functional magnetic resonance imaging

studies provide evidence for functional abnormalities in specific neural systems supporting emotion processing, reward seeking, and emotion regulation in adults with major depression.

B Summary of the literature on economic causes of depression

The related economics literature almost exclusively studies mental well-being as an outcome, often as a component of a more holistic view of well-being than conventional measures such as income or consumption. We provide a brief review of that literature here, discussing studies of the effects of unemployment, fear of unemployment, wealth shocks, crime and fear of crime, and social comparisons. For brevity, we focus on the studies that explicitly seek causal identification, through use of panel data techniques, natural experiments, instrumental variables or field experiments. Most studies use composite measures of mental well-being, but we highlight those that specifically measure depression prevalence or incidence.

Unemployment and fear of unemployment

It is well documented that depression rates are much higher among the unemployed, but causality could run in both directions. In our theory, we would interpret an unemployment shock (or fear of unemployment) as a shock to an individual's perceived future returns to her labor.

Clark (2003) uses the the British Household Panel Survey (BHPS) (from 1991/2-1997/8) and studies the GHQ-12 composite measure of mental well-being, which includes questions on depression, as well as “feelings of strain”, and insomnia. Mental well-being is significantly lower among the unemployed and among those whose partner is unemployed. In fixed-effects regressions he shows that mental well-being falls when an individual moves into unemployment and increases when he/she moves into employment.

Marcus (2013) uses the German Socio-Economic Panel (2002-2010) to study the impact of plant closures on composite mental health, measured by the Mental Component Summary Scale (MCS). Households that experienced a job loss due to plant closure during the period are matched on observables to households that did not, and the plant closure effect estimated by difference-in-differences. He finds approximately equal negative effects on mental health from own or spouse's unemployment – only in seven households did both members become unemployed so he cannot study the interaction considered by Clark (2003) (see below). Our framework focuses on private returns of a representative agent and cannot directly speak to depression induced by shocks to a close family member, except to the extent that they induce

pessimism about own returns.

Farré, Fasani, and Mueller (2015) use the Spanish Health Survey (2006 and 2011 waves) to estimate the causal effect of job loss on mental health. They exploit the collapse of the Spanish construction industry since 2007 as a source of exogenous negative to both short and long run employment for construction workers.¹⁹ Key outcomes of interest are diagnoses of, and self-reported, mental disorders (depression or chronic anxiety). In addition, they study responses to the GHQ-12 questions. The identification strategy is instrumental variables, with location specific exposure to construction as the instrument. They find a statistically significant 1.1 standard deviation in mental disorder diagnoses, and a 0.9 standard deviation in mental health as measured by GHQ-12. Closely in line with our theory, they write “[the shock] led to long unemployment spells, hopelessness and feelings of uselessness.”

Colantone, Crinò, and Ogliari (2015) use the BHPS (2001-2007) to study the effect of import competition in an individual’s industry on his/her mental distress, measured using GHQ-12. Using individual fixed-effects regressions, they find that a one standard deviation increase in import competition (defined as the ratio of imports to national consumption) in the individual’s industry leads to a decline of 0.13 standard deviations in the GHQ-12 index. Splitting out the components, they find particularly large effects on anxiety and depression, and. Analyzing mechanisms, they use a two step procedure to study how import competition feeds through to final mental health outcomes. They find support for the effect working through decreased job security, lower wage growth, and lower job satisfaction particularly regarding workload. We interpret these findings as closely aligned with our theory.

Wealth shocks

While our theory only considers wealth shocks that operate through the return to labor, the link we invoke from anticipated future consumption to mood also naturally carries over to shocks to non-labor income. We highlight two studies of the effect of stock market losses on the mental health of retirees.

McInerney, Mellor, and Nicholas (2013) study the effect of wealth shocks on mental health in the US Health and Retirement Study (HRS), exploiting exogenous

¹⁹They argue that a key advantage of this natural experiment (as opposed to plant closures) it enables the study of long-run effects since it was very hard for unemployed, low-education construction workers to re-enter employment, while those laid off because of a plant closure might re-enter employment differentially according to their (mental) health status.

variation in interview dates: some individuals in the 2008 wave were surveyed before the October stock market crash, and some after. They find that antidepressant use and self-reported measures of depression and mental health worsened after the crash. Notably the effect was strongest for individuals with high stock holdings. However clinically validated measures based on the CES-D showed no systematic effects.

Schwandt (2015) also uses the HRS to study wealth shocks, extending the analysis to the 1998-2011 waves. He constructs individual-specific exposure to stock market shocks by measuring individual stock market participation. He finds strong negative effects on both physical health and depression (using the CES-D).

Crime and fear of crime

One interpretation in line with our theory is that recent crime experience or exposure induces fear of future crime and which either directly reduces the return to labor effort (through theft or destruction of property) or indirectly because of lost productivity caused by the crime event, particularly when violence is involved.

Cornaglia, Feldman, and Leigh (2014) use the Household, Income and Labour Dynamics in Australia (HILDA) survey from 2002-2006, and measure mental health outcomes using subsets of the 36-Item Short Form Health Survey (SF-36). We are primarily interested in their Mental Health scale, using five questions that focus on depression and nervousness. In individual fixed-effects regressions, they find a negative relationship between recent experience of violent crime and mental health, and also between local crime rates and mental health. They find smaller, not significant effects from property crime.

Dustmann and Fasani (2016) study the BHPS, focusing also on the GHQ-12 index which they divide into separate components including an Anxiety and Depression component. In individual fixed-effects regressions they find that increases in the local crime rate harm mental health, including anxiety and depression. In contrast with Cornaglia, Feldman, and Leigh (2014), and closer in spirit to our theory, the effect of property crime is statistically significant while violent crime is not. Dustmann and Fasani (2016) also use data from the English Longitudinal Study of Ageing (ELSA) of individuals aged 50 and over, which contains a direct measure of depression, the Psychosocial Health Module (PSH) based on the Centre for Epidemiologic Studies Depression Scale (CES-D) which we also use. They find that increases in local crime rates, both violent and property crime, lead to increases in depression rates.

Socioeconomic environment

Our model considers only changes in beliefs about absolute returns, but could easily be modified to include shocks to beliefs about, and concern for, relative returns. We highlight two sets of studies that can be thought of as analyzing the effects of changes to peer group composition or outcomes on own mental health.

Katz, Kling, and Liebman (2001) study the two-year impacts of the well-known Moving to Opportunity program (at the Boston site), in which poor households were randomly assigned subsidies to move to low-poverty neighborhoods, or rent subsidies that could be used in any neighborhood. Income and employment did not change relative to control, but the predicted probability of a Major Depressive Episode²⁰ fell by five to ten percentage points (not statistically significant) from a baseline of 25 to 35 percent. Medium-run effects (four to seven years), studied in Kling, Liebman, and Katz (2007), are more positive – poverty rates declined and mental health outcomes, both for depression specifically as well as composite measures, improved substantially. The effect on mental health is also shown to be larger the lower is the poverty rate of the new neighborhood. Finally, Ludwig et al. (2012) study long-run effects (10-15 years), finding persistently lower poverty rates and (marginally significant) improvements in composite mental health. We note also that an additional channel discussed in these papers is through the fear of crime, and that fear of crime declined after moving to better neighborhoods.

In contrast with these positive effects of low relative socioeconomic status on mental health outcomes, a second set of studies suggests negative effects. Luttmer (2005) studies the relationship between neighbors' average earnings on individuals' self-reported happiness, and finds a negative effect, holding constant the individual's own income. Similarly, Baird, Hoop, and Özler (2013) and Haushofer, Reisinger, and Shapiro (2015) provide evidence of negative spillovers of cash transfer programs in Malawi and Kenya on neighbors' psychological well-being. Clark (2003), discussed above, studies the interaction between own unemployment and unemployment in three reference groups: the spouse or partner, household members, and the region. He finds a moderating effect: the mental well-being of the unemployed is higher when the unemployment rate among plausible reference groups is higher (spouse or partner, household members, region).

The two sets of findings seem to conflict – the Moving to Opportunity experiment

²⁰A measure constructed from the Composite Diagnostic Interview Short Form (CIDI-SF).

decreased the relative standing of the treated households relative to their neighbors, and increased mental well-being, while the remainder of the studies suggest an opposite effect of peer comparisons. However, Moving to Opportunity also improved the *absolute* prospects of the treated households as seen in the poverty and crime exposure results, and this may have outweighed the relative effects.